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SEEDS —

In this issue, and additional references

This issue of the *Arboretum Bulletin* is dedicated to various aspects of seeds, practical and theoretical. For obvious reasons it does not pretend to be a textbook on the subject.

A number of related articles have been published in previous issues of the *Bulletin*. Among them are:

Butterfield, H.M. 1967. Seed germination. 30(4):86-88.

Fordham, A.J. 1969. Propagation of woody plants by seed. 32(4):90-92.

Granston, Mae. 1968. Grow your own. 31(1):6-7.

Meeuse, B.J.D. 1973-1974. Seeds and fruits and their dispersal strategies. 36(3):11-17; 37(1):2-8.

Michaud, L.J., B.O. Mulligan and J.A. Witt. 1954. Germination of maple seeds. 17(4):121.

Miller, Altha. 1971. Growing alpines from seed. 34(2):18-19.

Thurman, Charles. 1971. Native alpines from seed. 34(2):20-21.

Witt, J.A. 1958. Seeds, their collection, cleaning and storage. 21(4):122-123.

Bibliographies following some of the articles in this issue will supply further references. In addition we wish to call attention to:

Barton, Lela V. 1967. Bibliography of Seeds. Columbia University Press, New York.

Thompson, P.A. and G.E. Brown. The seed unit at the Royal Botanic Gardens, Kew. Kew Bulletin 26(3):445-456.

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Summer 1978, Volume 41, Number 2

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COVER
Coffee bean necklace.
The triangular beads are hollow thorns of an acacia.
Courtesy of Mrs. B.J.D. Meeuse

Photo: Sigurd Olsen

Propagation of Horticultural Subjects From Seed

JOSEPH W. and
*MARGARET M. MILLER**

Cliff Lewis' seed flats with a glimpse of the garden behind. A propagator's delight, his wife's nightmare! Photo: Nancy Walz

Many gardeners recall that their introduction to their all-consuming hobby began in childhood with the planting of a brightly colored packet of flower or vegetable seeds. The sense of wonder one felt upon watching the tender green infants that promptly broke the surface of the soil has never really disappeared. That the dry and dingy seeds one planted could have contained in embryo those rapidly growing plants is a never ending miracle.

Although some very avid gardeners are content never to carry their plant propagation practices beyond the satisfaction of seed sowing, most eventually discover the delights of vegetative or asexual propagation. They learn that the unique characteristics of many desirable cultivated plants are lost when they are propagated by seed, and that it is only through such propagation techniques as cuttings, grafting, budding, layering and division that clones can be maintained.

This is by no means to imply that the advanced horticulturist scorns propagation from seed. Growing seedlings is the principal method of developing new cultivars. Many trees and other woody plants are more easily and economically produced by seeds than by any other method. Many very desirable plants are so scarce in cultivation that access to their vegetative parts is limited, whereas their seeds may be available by purchase or exchange. Seeds from overseas may be shipped rapidly by air with a minimum of red tape, while the living plants or vegetative parts encounter many bureaucratic hurdles.

Three major problems, exclusive of the propagation techniques themselves, confront the gardener who wishes to grow woody plants or herbaceous perennials from seed. These are the failure of many cultivars to reproduce the characteristics of the parent, the doubtful viability of some seeds and the intriguing problem of seed dormancy.

It should be understood that the variability within a batch of seedlings is a natural and valuable characteristic. Without this ability to vary in its progeny, a species could not continue to adapt to changes in its environment. Further,

*The Millers will be remembered for the excellent description of their work in revegetating Cascade Pass (see the *Bulletin* 39:4, 1976). When the Editorial Board asked them to undertake this project, they agreed to do so with alacrity and approached the subject with characteristic thoughtfulness and thoroughness. We thank them.

the existence of genetic variability has permitted plant breeders from the earliest days to improve species by selection, resulting in the marvelous variety of cultivated plants we now possess. Plants that are cross-pollinated are particularly prone to genetic variability in their offspring. Thus, we all know that we cannot plant a seed from a Golden Delicious apple and expect to grow a Golden Delicious apple tree. We *might* get an even better apple than Golden Delicious, but the odds are that it would be poorer. The same rule applies to most fruit and nut cultivars and to many woody ornamentals such as roses, camellias and hybrid rhododendrons. To many gardeners, though, this fact of genetic variability is the very thing that makes growing plants from seed interesting. We welcome the adventure in not knowing just how a group of seedlings is going to turn out.

The viability or longevity of seeds varies greatly between genera and sometimes even between species. Spring-ripening seeds of trees of the temperate zone are particularly short-lived, since in nature they are accustomed to germinating immediately upon dropping to the ground (3).[1] Poplar *(Populus),* silver maple *(Acer saccharinum),* elm *(Ulmus),* white oaks *(Quercus)* and willows *(Salix)* will germinate as soon as they fall upon the soil, willow seed within 12 to 24 hours following dispersal (9).

The following are some woody plant genera whose seeds are short-lived (10):

Acer (some species) (maple)
Alnus (alder)
Amelanchier (serviceberry)
Cedrus (cedar)
Cercidiphyllum (Katsura tree)
Chamaecyparis lawsoniana (Port Orford cedar)
Clerodendron (glory-bower)
Cryptomeria
Davidia (dove tree)
Franklinia
Halesia (silverbell)
Liquidambar (sweet gum)
Liriodendron (tulip tree)
Magnolia
Mahonia (Berberis, Oregon grape)
Myrica (bayberry)
Nandina
Nyssa (tupelo)
Populus (poplar)
Potentilla (cinquefoil)
Rhus (sumac)
Salix (willow)
Shepherdia (buffalo berry)
Spiraea
Stewartia
Styrax
Taxus (yew)
Ulmus (elm)

Nut seeds with large, fleshy cotyledons are very short-lived if they are allowed to dry out after ripening. However, seeds of *Aesculus* (buckeye), *Carya* (hickory), *Castanea* (chestnut), *Corylus* (filbert), *Fagus* (beech), *Juglans* (walnut) and *Quercus* (oak) can have their viability extended to two years by cool, moist storage. Acorn viability can be maintained for two and a half years by storage in sealed polyethylene bags at 39°F (7).

Fortunately for the gardener, fall-ripening seeds of both woody and herbaceous plants of the temperate zone have a natural viability lasting at least until the start of the next growing season. Species lacking this trait would long since have vanished from the earth. The propagator will assume that the seeds he has acquired, provided they are "fresh," that is from the current year's crop, are viable. His responsibility, then, is to maintain that viability until they are sown. There is an extensive literature on the commercial storage of seeds, but for the amateur, probably the easiest and best technique is storage of the seeds in a tightly sealed glass container with a minimum of air space in the home refrigerator.

The third major problem of seed propagation — dormancy — is a subject that has long fascinated botanists and plant physiologists. Perhaps because it is a field of inquiry particularly adapted to laboratory analysis, there has been a great deal of research and publication on seed dormancy.[2] While there are differences of opinion as to the exact causes of delayed germination in seeds and the means of overcoming it, all writers seem to agree that dormancy is of great survival importance to the plant. Plants whose seeds germinated at unfavorable seasons were selected against and have become extinct.

Dormancy in seeds may best be defined as a refusal of seeds of many species to germinate as soon as they are mature. The dormant embryo can only be activated by such factors as a time span to allow disappearance of chemical inhibitors or the effect of certain environmental conditions such as drying, moisture, cold, warmth, light or sometimes a rather precise alternation or combination of these conditions. There does not seem to be any uniform mechanism by which dormancy can be broken. The

[1]Numbered references are listed alphabetically at the end of the article.

[2]For a more complete discussion of the subject, see the article, "Dormancy and Germination of Seeds," by B.J.D. Meeuse (p.8).

reason for this is that presumably dormancy evolved independently in many separate groups of plants, each of which found a different means of insuring survival of its progeny (6).

Dormancy is no problem to the gardener who plants seeds of vegetables or annual flowers. Any transitory dormancy these seeds may have possessed at the time of ripening has been overcome by the normal handling in dry storage. Over the course of many centuries, commercial seeds have been artificially selected for their readiness to germinate rapidly, a trait that would be most hazardous to wild plants.

The problems of overcoming dormancy are much greater in seeds of native trees and shrubs or those plants recently introduced into cultivation. The seeds of approximately two-thirds of American tree species are dormant and will fail to germinate promptly when placed under favorable conditions of temperature, moisture and light (7). In the monumental handbook *Seeds of Woody Plants in the United States,* specific handling methods are given for seed of 188 genera. Of these, 63 percent are dormant when harvested. This percentage refers only to fresh seed; the seed of additional genera become dormant if subjected to unfavorable conditions of storage.

By contrast, several writers have found that only a minority of arctic and alpine species (20 to 40 percent) possess true dormancy. The balance will germinate readily, even in the laboratory, when conditions are favorable, generally at temperatures between 20° and 25°C (68° and 77°F). Their failure to germinate at lower temperatures is an evolved protective device to guard against premature germination during autumn or early spring (2). Seed coat inhibition is probably the most common cause of alpine seed dormancy; a requirement for stratification (exposure to moisture and cold for an extended period) or for after-ripening accounts for very little alpine seed dormancy (1).

Equally as fascinating as a study of the basic problems of propagation from seed is a look at the many ways good gardeners have learned to work with nature to grow their seeds. For discussion of the techniques of propagating trees, woody shrubs and alpine herbaceous perennials, we have interviewed three local experts who have agreed to share their knowledge and experience. While each of these individuals could speak knowledgeably on all three of these categories, for the purposes of this article, we have limited their contributions to one part only.

Trees

Our tree expert is Walter Lyon, horticulturist of the Carl S. English, Jr. Gardens at Seattle's Hiram M. Chittenden Locks. Mr. Lyon has spent the last 15 years at the Locks, during the first 10 of which he worked with the distinguished plantsman, the late Carl English. Prior to his government work, he had many years' experience as a nurseryman, including eight years with the old Richmond Nursery, familiar to many of our readers. For recreation he grows wine grapes and cares for an extensive collection of antique apple varieties in his five-acre garden in Bothell, Washington.

Mr. Lyon is a firm believer in the utility of growing trees from seed, pointing out that nearly all of the trees at the Locks, except a few of the older ones, have been propagated in this way. He carries on a seed exchange with arboreta and botanic gardens worldwide, contributing seed from the distinguished tree collection at the Locks. For a source of tree seeds for the amateur he suggests the seed exchange of the American Horticultural Society. Collection from the many varieties of trees in local gardens and parks is also a possibility, provided one can beat the squirrels to the harvest.

Walter Lyon believes that the best time of year to plant tree seeds is the day and month in which one obtains them. This is particularly true of seeds received by mail or from one of the seed exchanges. He would prefer to plant all his seeds in the fall to take advantage of the natural stratification provided by our winter weather, but if the seeds are obtained late, he sometimes stores them for a month in the refrigerator and then plants. He does not test for viability since most tree species are so tardy in germination that too much time would be lost before the balance of the seed could be planted.

Although he is a skilled professional, Mr. Lyon's propagation techniques have perhaps more relevance to the needs of the average amateur than do those practiced in the vast seedling factories operated by the U.S. Forest Service and the various state and provincial forestry departments. The garden at the Locks requires only a few examples of each species,

and there are not the same economic pressures to try to ensure simultaneous germination of enormous numbers of seeds.

Walter uses a variety of containers for his seeds — wooden flats and boxes, plastic pots and deeper nursery cans for taprooted species such as the oaks. He attempts to adapt soil mixtures to the requirements of the species, thus using a mix with sharp drainage for subalpine species and a predominance of mineral soil over humus for most conifers. He does not try to match the pH of the soil mix with the native soil of the tree species, reasoning that if the plant is going to grow here, it had better get used to our soil. He does not use the artificial soil mixtures used in containerized seedling production and he normally does not sterilize his soil unless working with a very rare and hard to obtain subject.

He places his seeded containers outdoors, under the shade of trees, on the north side of buildings or in a cold frame. He warns against putting containers under roof overhangs. In our normal winters, rainfall will keep containers uniformly moist, but this should be checked periodically. He never throws out the containers until after the second year, since a number of species have secondary dormancy or double dormancy and require a long period before germination will occur.

Mr. Lyon emphasizes prompt attention to the germinated tree seeds. They should be separated early before roots grow together and placed into the ground or into large enough containers to prevent root spiraling. Oaks, especially, should be removed from containers early, preferably when dormant, so that their deep taproots can be pruned. If oaks must be grown for several years in containers before being put into their permanent location, he believes that wire cylinders lined with building paper are suitable. These permit the taproot to grow into the ground rather than grow spirally in the container.

A good reference, he believes, is the old Forest Service *Woody Plant Seed Manual* (8) or its revised version, already mentioned in this article, *Seeds of Woody Plants in the United States* (7).

As is evidenced by the magnificent tree collection in the gardens at the Locks, the propagation techniques practiced by Walter Lyon and earlier by his friend and mentor, Carl English, have been more than successful. Nothing he recommends appears too complicated for the amateur gardener who wishes to grow his own landscape trees from seed.

Woody Shrubs

As our expert propagator of woody shrubs, we selected for interview Mareen S. Kruckeberg, whose MsK Rare Plant Nursery was described in the *Bulletin* two years ago (5). On a mild March afternoon of mingled sunshine and showers, the Kruckeberg's beautiful garden and Mareen's nursery were positive proof of their dedication and knowledge.

In the mist bench of her greenhouse Mrs. Kruckeberg propagates numerous rare cultivars from cuttings, but she finds many circumstances in which growing from seeds is necessary or desirable. Many woody species are difficult or impossible to grow from cuttings, and for some of her rare subjects from overseas, it is only by receiving seeds through the mail that she can hope to propagate them. She feels genetic variation in a batch of seedlings is extremely important to her. She carefully searches out the "runts of the litter" among the seedlings and grows on these naturally dwarfed specimens for her bonsai aficionados.

Mrs. Kruckeberg feels strongly that amateur gardeners, instead of digging in the wild, should collect and grow seeds of our more desirable native species. Other recommended seed sources of woody shrubs are the seed exchanges conducted for their members by the American Horticultural Society, the American Rhododendron Society and the American Rock Garden Society.

She normally does not test seeds for viability because of the time loss, but sometimes does crack open a few seeds of a batch to ensure they they are not just empty shells. She prefers to plant her seeds as fresh as possible, regardless of the time of year they are received. Sometimes, though, if the seeds come from a cold native habitat and arrive as late as February, she stores them in her freezer for a month and then plants them. In the event she wishes to save part of a batch of seeds over to the next year, she stores them in the refrigerator.

Her standard soil mix is composed of equal parts of aged screened compost, peat, perlite and vermiculite. The Kruckebergs rotate five compost piles of clippings, prunings and leaves (no kitchen wastes, which they dig instead into the

vegetable garden). She feels the small amount of compost in the mix gives the germinating seedlings a little food and makes it unnecessary to add fertilizer as soon as they emerge. She is also experimenting with a soil mix for some of her rarer subjects composed of equal parts of milled sphagnum and vermiculite with a little bone meal for nutrient.

As containers for her seeds, Mareen uses only styrofoam cups, cottage cheese containers and small rectangular styrofoam seed flats. She follows the old rule of thumb for depth of planting: cover to the diameter of the seed. She then covers each planted container with a thin layer of crushed white stone, called "turkey grit." This grit holds the seeds in place and protects them from washing from rain or watering.

Most of her seeds of woody plants are placed outdoors in a raised cold frame under high shade. A raised frame minimizes slug depredation and makes it easier to examine the containers for germination. The glass cover to the cold frame is closed only during extended spells of rainy weather. Under these conditions, damping-off or fungal diseases have been no problem to her. Liverworts growing over the seedlings have been a problem only in the greenhouse, not outdoors.

She keeps a sharp watch on the containers for germination and transplants the seedlings into wooden quarter-flats as soon as possible after they develop the first true leaves. They stay in the quarter-flats for a full year, and she then transplants them into appropriately sized plastic pots. For growing on the young transplants outdoors she fertilizes with Osmocote, a slow release fertilizer. Since this material molds in the greenhouse, she uses a liquid fish or Liquinox there.

Mrs. Kruckeberg has found that a number of species require two years to germinate. Various species of *Daphne* have this degree of dormancy, and she has had good success with planting *Daphne* seeds under the parent plant and letting nature take its course. During most winters the seeds she has placed in the cold frame receive adequate freezing to break dormancy, but she has placed containers of dry-country *Eriogonum* species in the freezer for a month before putting them outdoors. She has used sulfuric acid only to treat manzanita *(Arctostaphylos* spp.) seeds, which are notoriously difficult to germinate. She warns that seeds contained in a fleshy berry or fruit should be removed from the outer covering and cleaned to avoid mold damage.

Mareen contends that much of her success in propagating rare shrubs from seed has been due to common sense gardening practices and a lot of trial and error. As a good reference book for someone who wishes to delve more deeply into the subject, she also recommends the USDA handbook, *Seeds of Woody Plants in the United States* (7).

Alpines

Our third expert, Clifford G. Lewis, is an amateur who has elevated to an art the growing of alpines from seed. He confesses to being a "seed nut" and admits that, as of the date of the interview, he had over 300 lots of seed already sown. Cliff, of British birth, became bitten by the alpine gardening bug only after he emigrated to Washington. To continue pursuit of his hobby, he joined the American Rock Garden Society 11 years ago, and he is a past chairman of the Northwest Chapter, the Society's largest local group.

In addition to collecting in the wild seed of our choice western native alpines, Cliff obtains seed from the exchanges of the American Rock Garden Society, the Alpine Garden Society of Great Britain and the Scottish Rock Garden Club. He says that he orders his seed within a half hour of receiving the seed list in order to try to get some of the rarer and more desired subjects, and he sows his seed as soon as it arrives.

Mr. Lewis prefaced his discussion of his propagating techniques with the disclaimer that they might be "frowned upon by some very able people," but since they work for him, he plans to continue using them. He uses a soil mix composed of one part good garden soil, two parts old compost and three parts of sharp, coarse sand. His compost pile is a comprehensive one, containing leaves, grass, weeds and prunings as well as kitchen wastes. He uses no fertilizer in the seed mix but concedes that two ounces of superphosphate per bushel would be acceptable. None of his soil mix is sterilized.

All his seeding is done in small plastic pots which he fills to within one-half inch of the top. He sows the seeds thinly because otherwise one has "the devil's own job" of separating the crowded seedlings. He warns that many gardeners sow the entire packet into a container,

whereas he would prefer to store the excess seed in the refrigerator for another chance if something goes wrong. The pots are topped off with one-half inch of No. 3 traction sand (a coarse crushed granite grit) or one-quarter-inch pea gravel, and he then waters the pots from the bottom by placing them in a container of water. The covering of gravel helps eliminate damping-off and moss, and the little seedlings push right up through the rocks as though they were at home in the mountains.

The planted and watered pots are placed in a raised frame on the north side of the house. The raised structure helps to keep out slugs, and the glass cover, which is never tightly closed, protects against our excessively wet winters.

Cliff warns amateurs not to lose heart if the seeds do not germinate the first spring. Many subjects will not come up until the second year. Gentians, as an example, if not sown by the third week of January, will not germinate during the following growing season. He does not use any pre-conditioning techniques to break dormancy, relying on exposure to the elements to do it naturally.

When his seedlings have about four leaves, he transplants them individually into two-inch plastic pots, using the same mix as for seeding, with some additional compost. He turns out the entire pot of seedlings and uses extreme care in separating and repotting the young plants. His goal is to get these plants into the open ground during the same growing season, so they do not have long to stay in the two-inch pots.

The choice alpine bulbs are much slower growing than most of the other perennials and often take several years to reach blooming size. He handles these by filling a flat with soil two inches deeper than the pots. The pots of tiny, hairlike seedlings are tipped out and planted in the flat in clumps. They are then left for several years before being planted into the garden.

Cliff feels the most useful reference is L.D. Hills' *Propagation of Alpines* (4) but says he usually consults it only after he has drawn a blank with a batch of seeds to find out what he did wrong!

The foregoing discussion barely scratches the great and wonderful field of what the old-time plantsmen called "seedage." The published material on propagating from seed is so vast that a dedicated gardener could spend years of reading without exhausting the literature. In addition to the references cited by our three experts, we should like to mention Hartmann and Kester's *Plant Propagation, Principles and Practices* (3), which we have found to be a useful tool.

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Raised frame in the Lewises' work area.

Photo: Nancy Walz

Dormancy and Germination of Seeds

*B.J.D. MEEUSE**

Introduction

In the days of my youth, when slates — and the wet sponges for cleaning them — were still very much part of the educational scene, we were encouraged to germinate peas or beans in our little sponge-boxes. To witness the dynamic, poetic and altogether inspiring process of seed germination is indeed an educational experience of the highest order. Older people may feel that they have to come up with reasons for their interest in seed germination, but these are not hard to find. Indeed, if we wish to survive in the style we are accustomed to, it is wise to learn as much as we can about germination, especially in the case of our main food-crops and that of our fruit- and lumber trees, garden-flowers and -shrubs, house- and greenhouse-plants (some of which have seeds that are very hard to germinate), and — last but not least, for one must study one's enemies well! — weeds. It will be appreciated that our list leaves out very few plants! Nature lovers and biologists are, furthermore, delighted by the fact that many seeds "wait" for exactly the right signals from the environment before they germinate; the seedling ventures out only when it is safe to do so, i.e., when conditions for development are optimal. One could thus say that seeds often play it very smart. It is this *ecological* aspect of germination which we hope to emphasize in our article.

Dormancy and the Lack of Dormancy

Some types of seeds will germinate as soon as they come off the mother plant and find enough moisture. Nice examples are found in the genus *Cryptocoryne* of the arum lily family, popular as an aquarium plant. *Cryptocoryne ciliata* is abundant in the brackish tidal mud areas surrounding the Malay peninsula. The rcund seeds sometimes begin to germinate even before the fruit capsules, which are under water or raised just above the waterline, have opened. When the seeds fall or float out, the cotyledon or seed leaf has already been modified into a tuft composed of several narrow, dark green ribbons attached to the end of the seed; together these act as a floating organ permitting the seed to drift away. After a few minutes, however, the cotyledon becomes detached, and the seed immediately sinks down into the mud. The timing is "just right" to deposit the seedling a considerable distance away from the mother plant, while at the same time the risk of being carried away to the open ocean is avoided.

Especially in cold and temperate regions, but also in tropical areas with a very pronounced dry season, many types of seeds will, after having reached maturity, refuse to germinate immediately, even under ideal conditions. This is what we mean by *dormancy* (compare French and Spanish *dormir* = to sleep). A good example is birch. Early in the fall, when the seeds of most of our birches are ripe, temperature- and moisture conditions still are very favorable for their germination, but they do not respond. If they did, the vulnerable seedling would have to go through the harsh winter — not such a good idea! (Seeds in general are quite compact and dry, and are thus much better able to survive adverse conditions than seedlings are.) Clearly, the refusal to germinate, which strikes us as "clever" has survival value for the species; it is something which was selected for in the long process of evolution. It is due to the presence within these birch seeds of some *internal factor* which prevents germination. In many types of seeds, the internal factor is a chemical compund or a hormone (for instance, dormin or abscisic acid in peach seeds) which in laboratory experiments acts as a germination inhibitor. During the long winter months, the

*Dr. Meeuse's welcome articles on botanical subjects have become such a familiar part of the *Bulletin* that we feel it is no longer necessary to introduce him to our readers. His previous contributions were listed with his article, "Bribes, Decoys and Ant Guards," in the *Bulletin* (40:4, 1977).

inhibitor gradually disappears so that when spring with its ideal germination conditions rolls around, the seeds are ready to go.

Another advantage of dormancy is that it gives seed-dispersing agents (wind, water, birds, mammals) enough time to act. It is also an insurance against catastrophe, especially in those cases where seeds retain their viability for very long periods (sometimes for centuries, as in the case of the sacred lotus) and do not all germinate in the same year. Even if, over a wide area, the whole standing crop of a plant were wiped out, for example, by fire, flood or the consequences of volcanic eruption, the species would survive because in subsequent years individuals would continue to appear from those seeds which, safely hidden in the soil, survived the onslaught.

Man has been cultivating certain plants from time immemorial, and in general their seeds show much less dormancy than those of wild or recently domesticated species. Naturally! Dormancy is inconvenient for hungry people interested in quick results, and there has been a constant, deliberate selection against it. Winter cereals form an exception; their dormancy is an advantage, because it prevents preharvest sprouting.

The dormancy of weed seeds, on the other hand, is one of mankind's major headaches. These seeds may remain dormant in the soil for years or even decennia but may germinate and produce a huge weed-crop in fields that are regularly cultivated. The size of the problem is illustrated by the fact that one acre of arable soil in Rothamsted, England turned out to contain an average of 113 million viable poppy seeds *(Papaver rhoeas)* and 45 million viable seeds of the other main weed species!

Differential Dormancy

There are cases where one and the same plant individual produces two types of seeds: some which display no dormancy and others in which dormancy is more or less pronounced. This situation is fairly common in the goosefoot family (Chenopodiaceae), for example, in *Atriplex* and *Chenopodium*. The seeds that lack dormancy are relatively large and brown, while those with dormancy are small and black. The latter are produced later in the summer. The evolutionary advantage of the situation is obvious. These

The common dodo (male), mentioned on page 11 under "Influence of the seed coat." From a pen and ink drawing by Adrian van de Venne. 1626. University Library, Utrecht.

plants do not put all their eggs into one basket! The environmental factor which governs differential dormancy here, and in many other seeds as well, is *day length*. (In passing, we point out that this is also the factor which induces the leaf buds of birch and maple to become dormant in the fall. It is much more important than low temperature; in fact, when temperatures are *too* low, it is more difficult for the factor, day length, to exert its effect because metabolism then is depressed, and day length somehow works through metabolism.)

Incomplete Dormancy

When seeds of *Paeonia suffruticosa* germinate, a root emerges, but the shoot fails to follow suit. No further development takes place as long as the germinated seeds are kept at normal (fairly high) temperatures. However, if they are instead kept at a low temperature (1 to 10°C) for two or three months, in a moist condition, and then transferred back to normal temperatures, development will proceed without a hitch. Some species of *Asarum, Viburnum, Trillium* and lily *(Lilium)* display similar phenomena. Germination is even more complicated in seeds of lily-of-the-valley *(Convallaria majalis)*. At 25°C, root protrusion occurs, but it is much more pronounced if the seeds are first exposed to a period of low temperatures and then brought up to 25°C to permit root outgrowth. As soon as the first leaf has broken through its protective sheath, it enters dormancy, and a prolonged sojourn

at 5°C is required for its further development. (When given at an earlier stage, this treatment is ineffective.) The second leaf apparently also requires a low-temperature treatment for its proper development, so that in a natural habitat and under natural conditions it may take anywhere between 9 and 14 months before lily-of-the-valley seeds have produced complete, respectable young plants!

Secondary Dormancy

When seeds lose their readiness to germinate while retaining their viability, one can say that they have entered into secondary dormancy. The ecological significance of the phenomenon is again obvious — seeds should not put all their eggs into one basket! If, for some reason, they fail to germinate at the time of year which normally offers favorable conditions, they should "patiently" wait until a second chance presents itself, perhaps a year later. It stands to reason that at that time, or in the period just preceding it, the dormancy again has to be broken by the proper environmental signals. If the seeds kept themselves in readiness all the time, some chance event might trigger germination at the wrong time of year, with dire consequences.

An interesting illustration was recently provided by the Bascoms, who re-examined the case of the seeds which Dr. W.J. Beal used in his famous viability-experiment. In the fall of 1879, that gentleman, at what is now Michigan State University, buried freshly collected seeds of each of 19 herbaceous weedy species, including common ragweed *(Ambrosia artemisifolia)*. Fifty seeds of each species were mixed with moist sand in each of 20 one-pint bottles, which were kept buried at a depth of approximately 18 inches with the open mouth of the bottle facing downward. At regular intervals (5 years for the first 40 years, then 10 years) a bottle was dug up and its seeds were tested for germination. No ragweed seeds germinated in any of the tests until the 40th year, when two (four percent) germinated. It is highly significant that over the first 35 years the germination tests were always performed in late spring, summer or early autumn; the 40-year test was performed in early spring.

We now know that the seeds of ragweed, dispersed in the autumn, lose their dormancy in late fall and winter as the result of exposure to low temperatures. They will germinate in spring, provided of course that the external conditions for germination, including light (for many) are right. If they do not germinate, they enter into secondary dormancy, from which they will emerge only after another long period of low temperaures. So, the seeds of ragweed (and probably those of other seeds as well) go through an annual cycle; they move into and out of dormancy over a period of years until the seeds have either all germinated or have finally lost their viability. For ragweed seeds, the dormancy period in nature lasts from mid- to late spring until mid- to late autumn.

Internal Factors and Environmental Signals

For reasons both logical and convenient, we shall include "light" under the internal factors which affect germination; it has been found that illumination will in many seeds quickly lead to a change in the level of two closely related pigments, phytochrome-R and phytochrome-FR, and it is this change *(within the seed!)* which is more directly responsible for the germination behavior. (The R and FR refer to red and far red light, respectively.) "Influence of the seed coat" also belongs in this category.

Light. The seeds of most cultivated plants usually germinate equally well in the dark and in the light. Among wild plants, on the other hand, one finds quite a bit of variation in the behavior toward light. The seeds of some "insist" on darkness, while those of others require at least a brief illumination; still others have no preference one way or the other, and some require continuous light. Several species have so far been investigated, and at least half showed a light-requirement (which is not always an absolute one: it may depend on the prevailing temperature and may vary during storage). Examples of species whose seeds have a light-requirement are alder *(Alnus rubra)*, daisy *(Bellis perennis)*, dandelion *(Taraxacum officinale)*, evening primrose *(Oenothera biennis)*, fireweed *(Epilobium angustifolium)*, foxglove *(Digitalis purpurea)* and true sage *(Salvia pratensis)*. Darkness is needed, for example, by the seeds of tree-of-heaven *(Ailanthus glandulosa)*, delphinium *(Delphinium elatum)*, forsythia *(Forsythia suspensa)*, gladiolus *(Gladiolus communis)*, ivy *(Hedera helix)* and twinflower *(Linnaea borealis)*. Jimson weed *(Datura stramonium)* and anemone *(Anemone*

nemorosa) are indifferent as to the light-treatment.

The most extensive work with light-requiring seed has been done with a variety of lettuce *(Lactuca sativa* 'Grand Rapids') and with a pepper grass *(Lepidium virginicum).* The best type of light to promote germination (here as well as in other cases) is red light with a wavelength of 670 nanometers. So-called far red (wavelength around 730 nanometers) is inhibitory. Both the stimulation by red light and the inhibition by far red are reversible. Light from the sun, reaching the forest floor after having been filtered through several layers of leaves, is no longer white but represents a reasonably pure "far red" with a peak at 730 nanometers. Some investigators feel that the failure of seeds to germinate on the forest floor in this light has survival value; if germination did occur, the seedlings probably would perish!

Influence of the seed coat. In many cases, a seed's hard or leathery coat must be held responsible for the dormancy one observes. This can be demonstrated very easily by removing or damaging the coat; germination (i.e., development of the embryo) then quickly follows (see photo). There are at least four ways in which a seed coat can inhibit germination. It often acts as a straitjacket which restricts growth of the embryo mechanically; it may also deprive the seed of oxygen; it may block the entrance of water; and, finally, it may even contain high concentrations of germination inhibitors.

An example of mechanical restriction of the embryo by the seed coat is provided by the seeds of pigweed *(Amaranthus retroflexus).* Demonstrably, their strong coats are permeable to oxygen and water. It is probably the gradual weakening of the seed coats by microorganisms in the soil (a process that usually takes years) which makes eventual germination possible.

Seed coats impermeable to water are most widespread in the pea family (the Leguminosae). They can be very hard (even glassy) and resistant to abrasion, and may be covered with a wax-like layer. The entry of water into the seed is in some cases controlled by a small opening in the coat, the *strophiolar cleft,* which is closed by the so-called *strophiolar plug,* composed of a cork-like material. Water will enter the seed only if the plug is first removed or loosened in some way, an aim which can often be achieved by vigorous shaking ("impacting").

Other hard-coated seeds do not possess a strophiolar cleft. For germination, these have to be abraded in some way: mechanically, by chemical treatment (e.g., with sulphuric acid!), by microbial attack, by letting the seeds go through the digestive tract of animals, or by exposing them to an alternation of high and low temperatures which may cause the seed coats to crack.

A most spectacular, recently studied case of passage through an animal's digestive tract is that of the seeds of *Calvaria,* a tree belonging to the Sapotaceae which occurs on Mauritius, where it lived side by side with the famous dodo until that species of large fruit-eating bird was wiped out by man in 1681. For a few centuries, the *Calvaria* population on Mauritius has not been rejuvenating itself. Very recently, some seedlings have been obtained by substituting large turkeys for dodos.

Treatment with hot, or even boiling, water often proves to be a good method for small-scale (laboratory) experiments. In our University of Washington Botany Department, we apply it routinely to the seeds of Scotch broom *(Cytisus scoparius).* A considerable resistance to heat (and perhaps even an activation by heat?) is, of course, a prerequisite for success here.

The ecological implications are very significant. Forest fires, if not too severe, may — perhaps through steam formation — give rise to massive germination of Scotch broom seeds in the burnt-over areas. Another plant which may appear in numbers after a forest fire is mountain balm, *Ceanothus velutinus.* The fact that in both cases the young plants counteract erosion and enrich

Seeds of Scotch broom *(Cytisus scoparius).* Left seed coats unscarified and not germinating. Right: germinating after the seed coats were slightly damaged. Photo: B.J.D. Meeuse

the soil through fixation of atmospheric nitrogen is, of course, most welcome.

Rain- and depth gauges of seeds. We will wind up this narrative by presenting two cases in which seeds seem to be uncannily "smart." Since most seeds are small and do not swim or fly around once they have been deposited in the soil, they can "sample" only a very small part of their environment. After a long period of drought, the seeds of plants living in an arid environment should not immediately respond to the first signs of moisture; water from an insignificant rainstorm may have reached them through a crack in the soil while the bulk of their environment was still bone-dry and thus inhospitable. Seeds should germinate only when the upper soil-layers are uniformly wet as the result of long-lasting rain! How do they "know" that conditions are right? It seems that in at least some species a high level of water-soluble germination inhibitors provides the "gauge." The longer the rain lasts, the more water-soaked the soil becomes, with the result that the inhibitors will gradually be leached out until finally their level is low enough to permit germination.

In arid regions, the depth at which a seed finds itself in the soil can be of crucial importance for germination also. Moisture conditions are in general better in the deeper layers, but germination while being too far from the surface could be fatal for a seed since the seedling might not be able to reach the light in time to become self-supporting. Again: how does the seed "know" what the ideal depth is? The answer seems to be that at least some seeds pay attention (so to speak) to the particular temperature fluctuations they find themselves in. At the surface, such fluctuations are extreme, ranging from freezing at night to very hot in the daytime. Deep in the soil, we essentially find temperature constancy. In between, mild fluctuations occur, for example, between 15°C (night) and 25°C (day). Clearly, there is survival value in the ability to respond, by germination, to a regime of such mild fluctuations while remaining dormant under other temperature conditions.

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ERRATA

1. We wish to call attention to errors in two captions of the article, "Sexual Reproduction in Flowering Plants," on page 18 of the last issue (Spring, 1978, 41:1). Figure 7 (see inset at left) shows an *inflorescence,* or *catkin,* of *Alnus rubra* consisting of many flowers rather than one. Figure 8 (see inset at right) shows fruiting structures of the same species, each capable of containing a number of fruits.

2. On page 10, also of the last issue, we stated that the Strybing Arboretum received a specimen of *Nothofagus alpina* from the UW Arboretum in 1962. This date should be corrected to 1967.

3. In Volume 30, Number 3, 1977 we published on page 31 a review of Volume III of the important *Trees and Shrubs Hardy in the British Isles,* but neglected to mention that this is the famous reference work by W.J. Bean.

President's Message

The response to the Foundation letter of March 1st is very encouraging. We received, as of press time for this *Bulletin,* a total of 249 expressions of membership opinion. This number represents 8% of our approximately 3000 members. Many ballots represented more than one member (garden clubs, Arboretum Foundation units, family memberships, etc.) and so the response was probably better than 10%.

Of those responding, the overwhelming majority (94%) were in favor of the proposal to offer a portion of our funds toward the new Visitors' Center and other Arboretum improvements. Some very thoughtful comments and suggestions were received. Concern was expressed by 22% that the meeting room/guided tour assembly area would be too small and 9% commented on the probable inadequacy of support group office space (including the Foundation's). Some disagreement with the traffic pattern was expressed, too. Some 64% supported the proposal with no reservation.

Most comments on whether to support an alternate plan for Foundation facilities were in favor of staying in the Washington Park Arboretum; only a few suggested our renting, constructing or purchasing other facilities outside.

The Arboretum and Botanical Garden Committee is moving ahead on the Jones & Jones Update Plan. Your Board of Directors will be guided by the expressions of membership opinion in deciding how best to support the plan. The prospects are also good for rebuilding the tea house in the Japanese Garden.

There will be meetings of the University Board of Regents and of the Seattle City Council in the coming weeks. Seattle area members can assist in our mutual efforts by watching for these meetings and attending them when possible.

I am appreciative of the thought and concern expressed in these ballots. I shall continue to keep you informed.

Spring Horticulture on Display

"Spring Horticulture on Display," the first Unit Council Flower and Foliage Show, transformed the Thomas McCurdy Room at the Museum of History and Industry into a gardener's paradise. Thirty Units, the Arboretum, and Foundation members at large shared specimens of nearly 1500 plants. The wealth and variety of plant material available in the area was never more evident than in these displays.

To Joan Arnold (Mrs. Robert), Education Chairman of the Unit Council, goes credit for the idea and much of the success of the event. "It was like a gorgeous giant spring bouquet," she says.

The show was not judged, but a committee made up of Brian Mulligan, Jim Watson, Jacqueline Nehammer and Mareen Kruckeberg made the following unit awards: Best Artistic Display — Grace T. Dowling Unit 31; Most Unusual Plant Material — Houseplant Unit 84; Best Grooming — Vivian Mead Unit 66; Most Educational Exhibit — Frances MacBride Unit 41.

The Awards Committee also gave special recognition to the following individual exhibitors for outstanding material: Mary Dunnell, Unit 84, for *Heliconia humilis* (dwarf form); Jeanne Gardiner and Mary Johnston for *Trillium* 'Rivale' (pink form); Helen Moodie, Unit 57, for *Daphniphyllum macropodum;* Margaret Mulligan, Unit 41, for *Sarcococca ruscifolia;* Kitty Schwarz, Unit 41, for *Pieris japonica;* Yvonne Stoner, Unit 10, for *Leucojum vernum;* Mary Usack, Unit 84, for *Trichopilia suavis;* Marilyn Watts, Units 16 and 84, for *Rhododendron spinuliferum;* Jean Witt for *Erythronium oregonum.*

There are not many places where one can study so many different blooming species at one time. Displays included ground covers, bulbs, rhododendrons, camellias, magnolias, cherries, perennials, houseplants, and bonsai. A tape recording of bird songs made it seem even more like a garden.

The show surely accomplished its goal of being an educational adventure and could not help but whet the appetite of anyone interested in gardening. *RUTH MARY CLOSE*

Seed Collecting — advice from an expert

BRIAN O. MULLIGAN

Discovering the right time to collect seeds in a garden or in the wild is a matter of constant observation, watching the developing fruits of various plants as they gradually mature, subject to the influences of local climatic conditions

Woody Plants

The seeds of most woody plants will ripen later in the same year in which they flower: for example, *Daphne, Cornus, Forsythia, Prunus, Rhododendron* and other members of the family Ericaceae, *Ribes, Rosa* and *Stryax,* to mention only a few genera.

Some others, however, need a full year to mature, including the strawberry tree *(Arbutus unedo),* which flowers in October and November and ripens its fruits the following autumn when they are fully colored. *Skimmia* and *Sarcococca* species and hybrids flower in January to March, depending on weather conditions; their fruits should be collected when ripe early the following spring.

Our native madrona *(Arbutus menziesii)* flowers in May and ripens clusters of small red berries in October of the same year, at which time they are often very conspicuous on the trees until they are eaten by birds. Some cotoneasters, which flower in mid-summer, will take another six months to ripen their fruits: *C. lacteus (C. parneyi* of the nursery trade), for example, which is usually at its peak coloring about Christmas time.

Most conifers flower in spring, and their cones or fruits mature later the same year, including the hemlocks *(Tsuga* species), Douglas firs *(Pseudotsuga menziesii),* true firs *(Abies),* spruces *(Picea)* and larches *(Larix).* The small rounded cones of Alaska cedar *(Chamaecyparis nootkatensis)* often do not mature until late October or even November, depending upon the season and local conditions, especially in their native mountains. The true cypresses *(Cupressus* species), which grow from southwestern Oregon southwards into Mexico, take two years to mature their hard cones, as do most of our western junipers, with the apparent exception of the creeping *Juniperus horizontalis* from the Rocky Mountain states. Our pines also require two seasons to produce ripe cones.

It is often difficult to collect seeds of the conifers since the cones are usually borne at the tops of the trees or out on the ends of the branches where they are inaccessible; or the seeds may be shed before the cones fall, as in most of the pines, firs, hemlocks and larches. Sometimes, however, one is lucky enough to reach cones on low branches or find a young tree producing cones under poor growing conditions such as along the coast on very sandy soil, where one may find lodgepole pines, Sitka spruce and even grand firs *(Abies grandis).* Squirrels have also been known to assist the collector by cutting down cones from upper branches of pines and firs before they are fully ripe.

In the garden it is relatively easy to watch particular plants and gather their fruits or capsules when mature. This may be indicated either by their falling off branches, as in the case of most daphnes, species of *Sorbus,* many viburnums, *Cornus kousa* and the *Styrax* species. The native *Rubus,* including *R. spectabilis* (salmonberry), *R. parviflorus* (thimbleberry) and the white-stemmed *R. leucodermis* all indicate their ripeness by becoming yellow, red or purple, as the case may be, and succulent.

Many "berries" such as those of the hollies *(Ilex* species and hybrids), pyracanthas, the skimmias, *Crataegus phaenopyrum* (Washington thorn), and some late-ripening viburnums including *V. tinus,* will color by October but remain on the plants until weeks or even months later, until the birds finally take a fancy to them when the weather gets cold. With some hollies and the skimmias the birds rarely or never harvest the fruits.

In the large genus *Sorbus* there is an extended ripening season from August until November, depending upon the species. The native *S. sitchensis* will be ripe in September and may be taken by birds at that time, whereas the pink fruits of *S. hupehensis* will decorate the bare branches until November. The seeds of all such fleshy fruits should be cleaned before they become too dry.

Other plants which produce dry fruits or capsules, such as the mock oranges *(Philadelphus),* deutzias, weigelas, forsythias, lilacs, as well as members of the Leguminosae family which produce pods, will indicate approaching maturity by a change of color from green to yellow to brown or black, and very often by splitting along the edges of the capsule. Many spiraeas are also in this category, although some hybrids like *Spiraea* × *vanhouttei* set no seeds. The clustered capsules of *Ceanothus* should be picked when they are turning black.

The various species of *Euonymus* are conspicuous with their orange- or red-colored seed coats when the fruits open. Magnolias usually show their similarly colored seed coats as the carpels of the fruits split open. The cones of magnolias should be picked as soon as any fall off the shrub or tree, from October onwards. The outer coats should be removed before sowing, which should be done promptly unless the seeds are stored in a refrigerator.

It is often possible to cut off entire dry inflorescenses of the native ocean spray *(Holodiscus discolor),* of *Spiraea* species, the native mountain maple *(Acer glabrum* var. *douglasii),* and of other plants which lend themselves to this practice, dropping them into a paper bag held beneath.

Capsules of the native *Rhododendron macrophyllum* should be collected as soon as they turn brown and split open in August — the first of this huge race to do so. Many species or hybrids of *Rhododendron* are slower to ripen and may have to be brought indoors while still green, but should be left on plants as long as possible, keeping careful watch on the color and condition of the capsules.

Other ericaceous shrubs will also come later, including *Ledum groenlandicum, L. glandulosum* from mountain meadows or stream sides, the false azalea *(Menziesia ferruginea), Phyllodoce empetriformis* and *Cassiope mertensiana.* All of these have exceedingly fine seeds which must be carefully handled when collecting the capsules. The fleshy berries of *Gaultheria shallon* (salal) and the other two native species are more easily picked.

Fruits of both eastern and western dogwoods *(Cornus florida* and *C. nuttallii* respectively) should be collected as soon as they begin to fall from the trees, or even earlier, as soon as the red seed coats can be seen in the fruit clusters, in order to forestall harvesting by the evening grosbeaks. The eastern species appears to fruit only irregularly and usually sparingly in the Puget Sound region.

Unripe fruits of *Garrya fremontii* in garden of Page Ballard, June 1962. Racemes three inches long. Cf. articles pp. 29-31. Photo: Brian O. Mulligan

The nut-like fruits of the silverbell or snowdrop tree *(Halesia tetraptera)* change from green to brown as they mature in October, but will remain on the tree for some time unless dislodged by wind or eaten by squirrels. This is true also of the woody fruits of the empress tree *(Paulownia tomentosa)* and the slim pods of the catalpas.

Amongst climbing plants the clematis are perhaps the most important. Most of these ripen their silky-tailed seeds from August to October or even November depending upon the species or hybrid concerned. The entire seed head can be removed when dry and stored in paper bags until required. If sown and left outdoors through the winter, they can be expected to germinate in the spring. Otherwise storage in a refrigerator until the following spring is advisable for all seeds.

Herbaceous Plants

Most of these have to be carefully watched and the ripening fruits of old flower heads cut and placed in paper bags as soon as there is evidence of approaching maturity. This may be either by capsules splitting open, as in lilies, fritillarias and veratrums in the Liliaceae, or in aquilegias, delphiniums and hellebores amongst the Ranunculaceae. Alternatively their color may change from green to yellowish to some shade of brown, as in some campanulas, verbascums and

many primulas and meconopsis. A third indication may be the conspicuous development of some means of transportation for the seeds such as the pappus on the seeds of members of the Compositae (for example, *Aster, Erigeron, Tragopogon),* or the silky tail formed by *Pulsatilla* species, or the even more silky hairs of fireweed *(Epilobium angustifolium)* and its relatives and of the milkweeds *(Asclepias* species) which will blow away at the slightest breath. All these last need especial care to avoid losing seeds when transferring them to temporary containers.

Genera with many species such as *Iris* or *Penstemon,* both cultivated and found in the wild state, will ripen at different times according to the species involved and the location. *Iris tenax* and *I. innominata* may open their capsules rapidly over a short period of hot weather in July, whereas those of the European *I. foetidissima* will not display its bright red seeds until late October or even early November. In the wild, such genera as *Lewisia, Phlox* and *Viola* have to be gathered as soon as any are found to be ripe, or if possible, more than once at short intervals, if many seeds are to be obtained before they are shed.

When collecting in the wild the harvest will of course depend upon what plants are forming seeds at any given time in a particular area. It pays, therefore, to have been over the ground earlier in the year when they (or some of them at least) are flowering, noting what is to be found at different locations and elevations. Scattered bulbous plants such as *Calochortus* and *Fritillaria,* and even some species of *Erythronium* are not always easy to relocate amongst other herbs and grasses when they form their fruits. Especially good color forms should be carefully marked with tags. In the northwestern states, ripe seeds may be found at lower elevations from late June until the snow flies in the mountains in October or even earlier. It is therefore always wise to be prepared not only with observant eyes but also with a supply of envelopes, bags and suitable boxes for whatever may be found worthy of collection, either for personal use or to pass on to others. ♠

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— From Dr. F.G. Meyer, Supervisory Botanist in charge of the Herbarium, U.S. National Arboretum, Washington, D.C.

Seeds and Seed Products
Their Ornamental Uses

*SAGE CULPEPPER BELT**

A "seed" in the language of botany is more precisely defined than is the layman's understanding of it. Therefore, seed-like fruits that have important ornamental uses have been included in the following article. Similarly, ornamental uses of seeds are not necessarily restricted to their primary incorporation into objets d'art. *For example, a dye derived from a seed is an ornamental use of its products. The author has included supplementary information regarding other economic uses of the plants described; to have ignored them would have been to lessen the significance of those plants.*

It may be noticed that not all the subjects of our illustrations have been mentioned in the text. As the author states in her closing paragraph, "the list grows too long." Art is subjective, and everyone's perception of ornament is, to a degree, unique.

The seeds or seed-like fruits of many plants are important to the artist and the craftsman. They are valuable for the beauty of their form or color and can also be the source for tools or decorative materials. In addition, some of them have ancient symbolic meanings while others have many economic uses.

BEAD TREES

A number of species occur widely in the tropics, having been introduced around the world perhaps because they produce seeds or seed-like fruits which are avidly sought by craftsmen for jewelry or for decorative accents on sculpture, masks and useful objects.

A recent search through the Pacific and African collections of the Museum of Cultural History at the University of California at Los Angeles recalled early memories of the seed leis for sale in stands along Kalakaua Avenue in Waikiki. There were, among others, *Erythrina* species, *Adenanthera pavonina, Abrus precatorius* and *Coix lacryma-jobi* — plants which produce some of the most beautiful beads found in nature, seeds remarkable both for their indestructibility and for their brilliant or delicate color.

Erythrina species

"Wili wili" trees, as they are called in Hawaii, provide the red or reddish-orange seeds used by lei-makers. Two species of *Erythrina* are also known as coral trees in tribute to their brilliant blossoms.

The "true" wili wili, *E. tahitensis (E. monosperma)* with pale red, orange or yellowish flowers, produces seeds that were formerly used for beads or jewelry. They seem now to have been replaced by the dark red seeds of the similar "wili wili haole" ("haole" is a local term used to designate an import). This deciduous legume from Asia, *E. variegata (E. indica)* is called the Indian coral tree or tiger's claw because the pods resemble feline claws. It flowers in January and February.

The seeds are poisonous when raw, but are said to be edible when cooked. They are used in some areas of the world, along with *Erythrina* bark, to stupefy fish.

Adenanthera pavonina

Another bead tree, called the "false" wili wili in Hawaii, is *Adenanthera pavonina.* The curling pods one sees high in its branches contain small bright red lens-shaped seeds. Also from Asia, this tall tree has delicate feathery foliage and a smooth gray trunk. A fine specimen grows across

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the street from the Honolulu Academy of Arts in Thomas Square.

Its strong wood is sometimes substituted for red sandalwood. The seeds, which are also called "barricari" or Circassian seeds, are edible and are used as a condiment in Malabar. They are used medicinally in Africa and for gold and silver weights in India.

Abrus precatorius

The creeper, *Abrus precatorius,* is often found in the tropics. Its seeds are called, among other things, "jequerite" or crab's eyes. Depending upon the variety, *Abrus* seeds exhibit several color variations which include red with a black eye or white with black. They are often used in the South Pacific to outline design areas on masks and sculpture. The similarity of the small red and black seeds to those of certain erythrinas is perhaps the reason that seeds from both genera are sometimes called "jumbie" beans.

Abrus seeds are used in African art and witchcraft. It is related, for instance, that sorcerers in certain areas insert them in place of ears when making effigies of intended victims. Such a practice may be related to the extremely toxic properties of the seeds, which contain abrin. For this reason the use of the seeds in jewelry is now prohibited in the United States.

Coix lacryma-jobi

Coix lacryma-jobi, Job's tears, is another craftsmen's plant now widespread although it is native to India. The seeds, or more properly seed-like fruits, are contained in a stony involucre or bract. Artists use them for necklaces and to decorate objects such as gourds or baskets. The small, glossy beads are green when young but as they mature, the color changes to delicate shades of blue, brown or purple, depending upon the variety.

Parents in some societies place a necklace of these lovely beads around the neck of an infant in an effort to ward off teething problems. Indeed, in Hawaii some consider *Coix* necklaces to be curative charms.

Called "adlay" in the Philippines, *Coix* fruits are edible and, when ground, can substitute for a certain amount of flour in bread or pastry. People in parts of East Asia use the seed-like fruits for a cereal food, parching and grinding them or boiling them in soup.

Leucaena glauca

One more plant which is basic to seed art in many areas of the world is *Leucaena glauca,* so-called for its silvery appearance. Both names are derived from Greek roots: *leuco* comes from *leukos* meaning white or shining; *glauca* is derived from *glaukos,* which means gleaming or bluish-gray, an apt description of the foliage of *Leucaena glauca.*

Artists use the shiny brown seeds of *Leucaena* both alone and in combination with those from *Coix, Abrus* and the various erythrinas. Called "haole koa" (true koa is a species of *Acacia)* or false koa in Hawaii, *Leucaena* has naturalized in waste spaces where it often grows with the guava and where it covers the lower hillsides of many valleys in the islands.

Peoples in various parts of the world cook and eat *Leucaena* seeds and pods with rice. The plant is grown for fodder in Hawaii where it is considered a good source of protein, but in some areas where the soil is rich in selenium, consumption of the foliage and seeds causes loss of hair and eventual blindness.

VEGETABLE IVORY

Vegetable ivory, a substitute for true ivory, is valued in the tropics as a material for carvings. It is obtained from the hard endosperm of the seeds of certain palms.

In the Pacific, these species are *Mauritia flexuosa (M. setigera),* the moriche palm, and *Metroxylon amicarum,* the steinnuss palm. A large tree, *Metroxylon* grows in the Carolines and other Pacific islands. Samoans use its trunk as one of the sources of the starch, sago.

In South America, vegetable ivory is obtained from two other palms, the Brazilian *Attalea funifera* and *Phytelephas macrocarpa,* which is found in damp localities. The hard seeds of *Attalea* are commercially known as coquilla nuts or "corozo." Those of *Phytelephas* are imported into Britian under the same name, corozo, but they are also known by a number of other local names in Ecuador where *Phytelephas* is an important crop plant.

* * *

These intrinsic decorative qualities such as color and durability, subtle form or curious shape, make seeds and seed-like fruits invaluable to the

artist. However, they have other attributes which can be used for ornamental purposes.

TOOLS

Primitive and contemporary potters frequently use seeds or seed pods to impress designs in their pots or to burnish them. The various *Eucalyptus* pods make handsome impressions as do many others. Some seeds make excellent "roulettes," enabling the potter to roll a design across his clay. Cones and pods are convenient for texturing.

Pandanus

Pandanus, the screw pine, or "hala" in Hawaii, is found throughout the Pacific. Its drupes are made into small brushes by softening the fibrous ends and are thus used to paint designs on tapa cloth made from the paper mulberry. They may be strung into leis as well.

In addition, the leaves of *Pandanus* are a source of "lauhala," the material from which the Hawaiians weave containers and mats, often of extreme flexibility and delicacy.

DYES, PIGMENTS AND OILS

Certain dyes and pigments are derived from seeds and the tissues surrounding them. Navajo weavers in the southwestern United States make a brown dye from walnut hulls and seeds, as well as an orange-brown one from the dried berries of sumac *(Rhus trilobata).* Even the common bean *(Phaseolus vulgaris)* is reputed to produce a dye.

Bixa orellana

The Aztecs obtained from the aril of *Bixa orellana* an orange-red dye which is still in use today. *Bixa* is, in fact, known as the annatto dye plant. Its fruits contain fifty or more ovate scarlet seeds which are used to dye cloth.

Bixa seeds are also used as a colorant for chocolate, margarine, paint and soap. The dye is tasteless and bright yellow. The bark of *Bixa* furnishes fiber for cordage, its stems produce eraser gum and its pods are sought for dried arrangements. In Brazil, people feed the seeds and pulp to bulls to make them more ferocious in the bull ring!

Semecarpus anacardium

Inks and varnishes are refined from the seeds of *Semecarpus anacardium* which grows in India. It is called the marsh or marking nut, a name which recognizes its use as an ink that is produced from the sap of the immature fruit when mixed with quicklime. This juice is in addition a valuable source of varnish.

Photo: Sigurd Olsen

Detail of a necklace made from the seeds of *Leucaena glauca*. Courtesy of Mrs. B.J.D. Meeuse.

Closely related to the cashew *(Anacardium occidentale),* it has a similar poisonous effect on the skin of those who are susceptible.

Aleurites moluccana

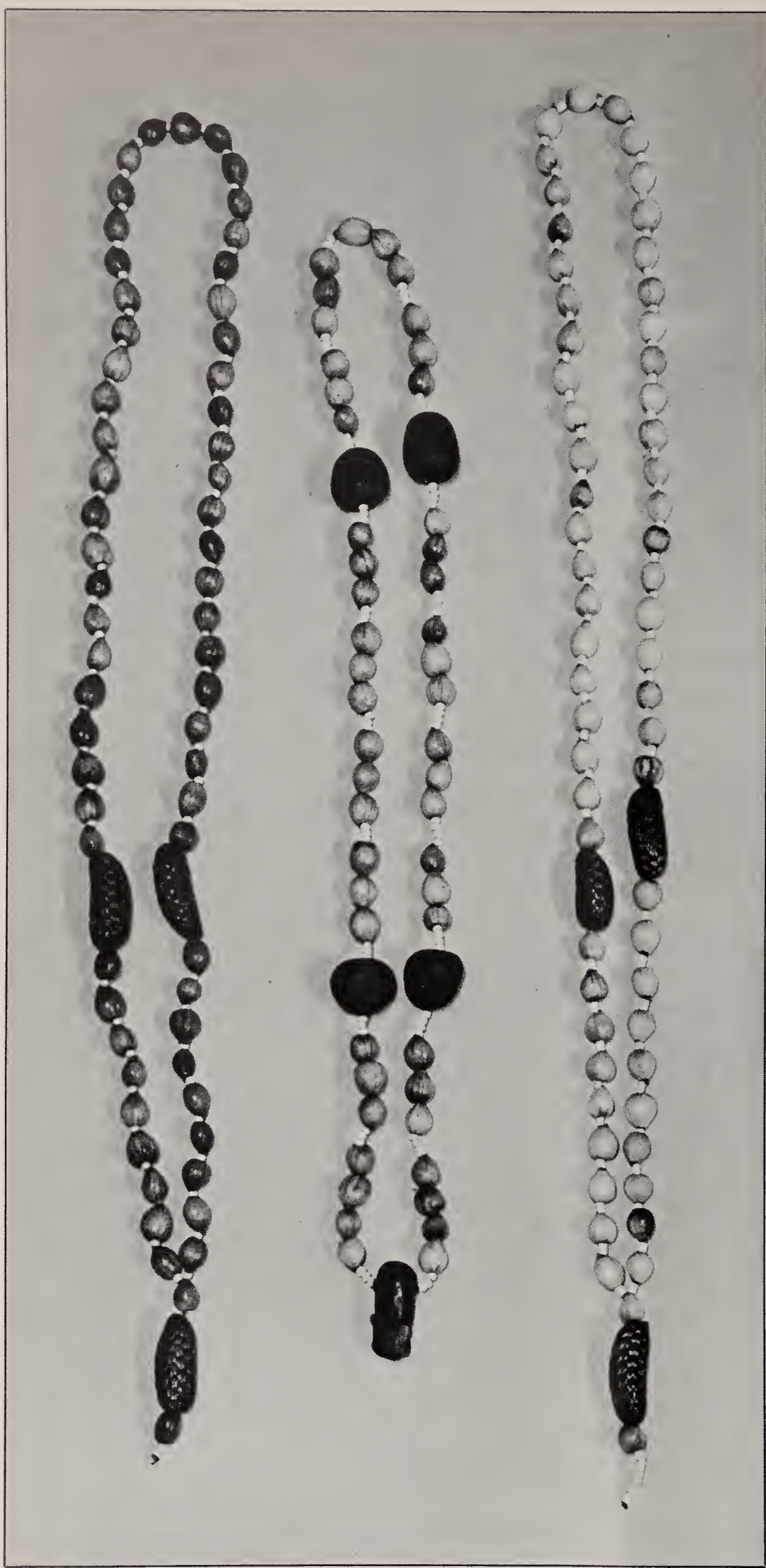
Aleurites moluccana, the candlenut tree, has multiple uses. Known in Hawaii as the "kukui" nut tree, its seeds produce both dyes and varnishes as well as an oil used in stone lamps. In fact, the kernels themselves may be strung on a wick to make candles. They are, in addition, processed into medicine, relish and fertilizer. *Aleurites* husks and roots provide dye and fiber for tapa cloth.

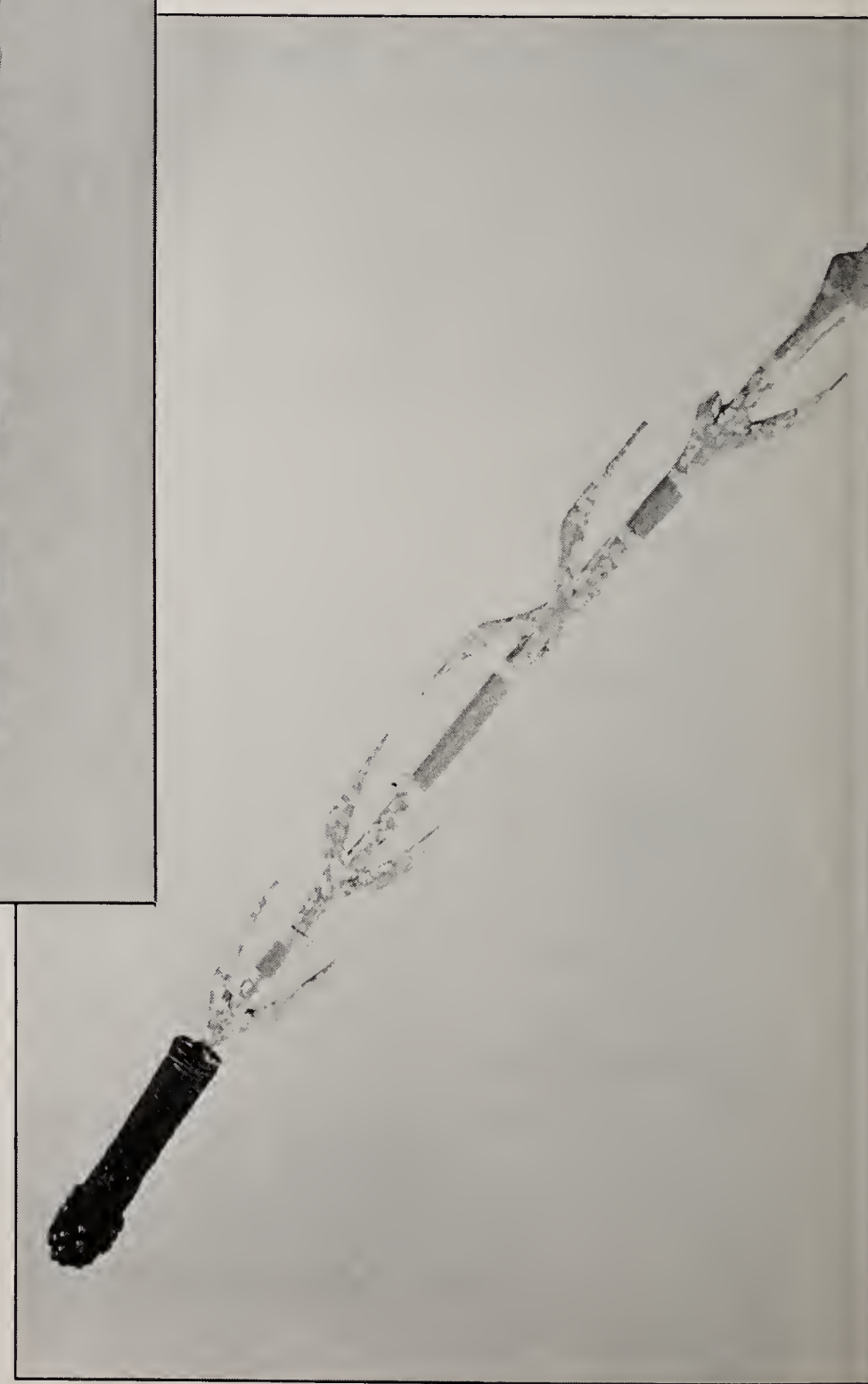
And, as if this were not enough, the hard black nuts are carefully polished and strung into a lei which is among the most valued of all seed leis! And so we have come full circle to one of the most frequent ornamental uses of seeds — the beads which are combined to make beautiful necklaces and leis.

But the list grows too long. Suffice it to say that the plant world contains many good providers. Man's curiosity will continue to discover new uses for the seeds of flowering plants. ♠

(See illustrations on following two pages.)

Some examples of seeds and their fruits in art





Above: Three necklaces of *Coix lacryma-jobi*. The cone-like beads are palm fruits. The pendent bead in the center is probably the arillate seed of a member of the family Connaraceae. The Job's tears vary in color: the two necklaces on the left are in shades of light brown; that on the right is gray with a hint of lavender. Courtesy of Mrs. B.J.D. Meeuse. Photo: Sigurd Olsen.

Top right: Ceremonial hat covered with *Abrus* seeds. Nigeria. Far left: Spear from the North Australian coast. The cover of the spear head is set with *Abrus* seeds. Left: Chief's necklaces (Ula's) made from the drupes of two species of *Pandanus*. These objects are in the collection of the Thomas Burke Memorial Washington State Museum. Photos: Priscilla Wagener

How Trees Defend Their Seeds

"*Sciurus hudsonius* Pennant" (*Tamiasciurus hudsonicus*). Plate 17 in John Richardson, *Fauna Boreali-Americana; or the Zoology of the Northern Parts of British America*. Vol. I. Engraving by Thomas Landseer. John Murray, London, 1829. Special Collections, Suzzallo Library.

*CHRISTOPHER C. SMITH**

Seeds as Prey

Seeds from wheat, rice and corn in the grass family (Gramineae) balanced with those from beans, soya beans and peanuts in the pea family (Leguminosae) are the staple diet for the majority of human beings (Heiser, 1973). The high food value of these seeds is not unusual: as a stage in the life history of higher plants, seeds are adapted to store enough energy for the growth of the first functional roots and leaves of a new plant until it can start to gain its own energy by photosynthesis. Seeds are also a major dispersal stage in the life history of higher plants. Therefore, it is an adaptive strategy to have the energy that is stored in the seed as concentrated and as lightweight as possible so that seeds can be more easily transported. It is this concentration of materials adapted for the early growth of the plant that is also so nutritious for the growth and health of human beings and other animals. Cultivated crops have been artifically selected through controlled breeding to produce seeds that are easily harvested and so that the nutritious kernel can be easily separated from the surrounding seed coats and fruit. In nature, selection has worked in exactly the opposite direction to make seeds more difficult to eat.

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While the food value of seeds makes them very desirable prey for animals, they probably do not fit the average stereotype of prey. For most people, predator-prey interactions bring to mind a chase between lion and zebra, fox and rabbit, hawk and sparrow or some other pair of mobile animals. Animals are so different from seeds or mature plants in the defenses they have evolved to avoid being eaten that the term "prey" is generally reserved for animals and the terms "carnivore," "granivore" and "herbivore" are employed to differentiate between predators that feed on animals, seeds and mature plants.

Seeds, as prey, have some of the general properties of both animals and mature plants. Mature terrestrial plants are large, green and immobile, which means they are easy to detect and cannot flee their predators. Animals can often camouflage themselves against inanimate backgrounds and can take flight when detected. While seeds cannot flee when detected, they do move once when dispersed and the timing of this move may be a critical part of their strategy for escaping predation as will be seen in some of the examples to follow. Before they are dispersed, seeds are in predictable positions on the parent plant and cannot easily avoid detection. However, once they are dispersed they are much less concentrated and can profit from camouflage.

Mature plants are able to defend themselves from herbivores in two basic ways: 1) plants have an indeterminate growth pattern which

allows individuals to survive and grow while they are being grazed by animals, and 2) they have a variety of traits that make them unpalatable in comparison to animal flesh. These traits include a high percentage of indigestible cellulose and lignin in their tissues, secondary plant substances which act as repellents or metabolic poisons to herbivores, and mechanical structures such as spines, hard tissues or sticky tissues that inhibit the chewing activities of herbivores. Animals generally sacrifice these defenses for a highly organized neuromuscular system. Although it allows them to forage and to flee their predators, this neuromuscular system is destroyed if they are caught, for it is made of the materials needed for animal growth.

Seeds are generally small enough relative to their predators that they are killed during predation just as an animal is. The materials stored in a seed to support the early growth of a plant are very digestible and often rich in proteins needed for predator growth. However, this nutritious kernel is often surrounded by hard seed coats and other reproductive structures which make the seeds as a whole indigestible. These surrounding structures are usually mechanically difficult to chew through. Moreover, all parts of the seed may contain materials that are poisonous to herbivores.

Escape in Time

On the whole seeds are probably not as effectively defended as either mature plants or animals. However, seeds have one additional strategy that is usually not available to mature plants and animals: they may be present in an area for only a short period between the time they are produced by the parent and the time they germinate, converting their stored energy into the woodier tissue of a seedling. A population of granivores is faced with the problem of finding alternate foods during the time that the seeds of their preferred species are not available. Long-lived perennial plants may heighten the granivores' dilemma by not producing seeds every year.

The trait of having huge mast crops every two to seven years interspersed among mediocre crops or near crop failures is characteristic of most of the conifers of the Pacific Northwest. Not only does the vast majority of individuals within one species of conifer have a large mast crop during the same year, but those species, such as western hemlock *(Tsuga heterophylla)*, Douglas-fir *(Pseudotsuga menziesii)*, grand fir *(Abies grandis)*, Sitka spruce *(Picea sitchensis)* and western redcedar *(Thuja plicata)*, all of which require one year for maturation of female cones, vary their mast production in phase which each other (Garman 1951, 1955). The trees are apparently able to keep in phase with each other by having the initiation of male and female cone buds respond to broad weather fronts that affect coastal forests from Oregon to British Columbia (Lowry, 1966). Western white pine *(Pinus monticola)* does not keep seed production in phase with the above conifers because it takes two years for female cone maturation (Garman, 1955).

These conifers do not store energy for their unusually large mast crops, but rather divert it from building woody support tissue in the trunk and branches. Eis *et al* (1965) found that growth rings in Douglas-fir trunks were significantly smaller during mast years, but normal for the years preceding and following them. Thus, there is no need for costly storage of energy by the trees in order to vary their seed crops and starve their seed predators. There is also evidence that some of the weather conditions which correspond with large mast crops also favor the seedlings that result from the crop (Smith, 1970). Large crops tend to follow dry springs which tend to dry out and kill roots in the upper soil layers. Thus, seed dispersed from cones in the autumn after these dry springs will fall on a soil with a minimum of surface root competition for the seedlings that germinate the following spring.

Predator Responses

Whatever the extent of adaptation to germinating conditions and patterns of trunk growth, the trait of periodic huge mast crops separated by small to nonexistent crops has a very marked positive effect for the trees by greatly reducing the populations of their seed predators. This effect became clear to me during three growing seasons I spent studying the pine squirrels in the genus *Tamiasciurus* in the Cascade Mountains of southern British Columbia. There had been a large mast crop in 1961, the year before I first visited the mountains. The squirrels, which store green cones in the center of their individual territories in the fall as a source of winter food,

Photo: C.C. Smith

Lodgepole pine cones in groups of 4. Clockwise from upper R.: uneaten cones; those eaten by red squirrels *(Tamiasciurus hudsonicus)* who have very strong jaws; cones eaten by Douglas squirrels *(T. douglasii)* whose weaker jaws allow them to attack only the softer scales; those fed to red squirrels caged and fed on peanut butter for several months.

still had large supplies of cones in their caches in the spring of 1962 when I first came to the mountains. However, the squirrels appeared to have harvested only a small fraction of the 1961 cone crop because there were large numbers of empty cones still on the trees whose seeds had been dispersed before squirrels could cut down the cones. There were also parts of the forests in which no squirrels had established territories. It appeared that in 1961 there had not been enough squirrels to harvest most of the cone crop.

The reason for the absence of squirrels became clear as I studied them through 1964. Most species of conifers had small crops in 1962. The squirrels had had enough cones stored from 1961 to supply nutrition for large litters in 1962, and the squirrel population was large enough to fill all the forests which had cone crops in that fall. In the areas that I studied, squirrels harvested all the cones in their territories except about half of the western hemlock. In 1963, there was essentially no crop in any conifer except lodgepole pine *(Pinus contorta)*. There was no squirrel reproduction and most of the adults emigrated out of conifer forests other than lodgepole pine. During a 40-mile hike which I took to census squirrels in the area east of Ross Lake, Washington, I walked for periods of over an hour without seeing or hearing a squirrel. But, when I came to rock slides covered with maples *(Acer)* and alder *(Alnus)* numerous squirrels were chasing each other and giving the calls that are related to territorial behavior (Smith, 1968). The same was true in stands of lodgepole pine.

In 1964 there was a large crop of cones in all species of conifers. Squirrels moved back into the most productive stands of conifers, but as in 1961, large areas of forest had no squirrels in them and a large fraction of the 1964 crop was untouched by squirrels even in the areas they had moved into. In the forests on the western slopes of the Cascades where lodgepole pine is rare, the largest numbers of squirrels reinvading other conifer forests were found near the few stands of lodgepole pine that I discovered. In collecting squirrels for study, my hunting success in forests away from lodgepole pine dropped by a factor of ten between spring of 1963 before squirrels moved out of the forests and the spring of 1964 when they were moving back. It is likely that variation in the size of cone crops may cause at least a ten-fold variation in the size of squirrel populations and allow a large fraction of the total seed production to go uneaten.

The variation in mast crops affects other seed predators just as it does squirrels. Populations of deer mice *(Peromyscus maniculatus)* become very low during crop failures and are unable to exploit much of the large crops that follow. However, mice may be a serious problem in reforesting clear-cut areas in logging operations because, unlike squirrels, they can maintain large populations on the weed seeds produced in the cleared area and therefore can more effectively exploit the conifer seeds falling into the cleared area from the larger seed crops.

Each species of insect generally exploits fewer species of seeds than does the average species of vertebrate, and the most serious insect threats to conifer seeds attack the seeds while they are developing in the cone. Thus, insects are less likely to be able to exploit alternate foods during cone failures. It might appear that a regional cone failure could effectively eliminate an insect species that preyed on seeds. However, Keen (1958) points out that

most species of insects that attack conifer cones have a variable length of diapause, or period of dormancy, some time between the larval stage and the adult reproductive stage. Within the same species population of seed predators most remain dormant through one winter, a few through two winters and a summer, and an even smaller fraction through three winters and two summers. The effect of this pattern is that even if there is a nearly complete cone failure some years, there will be some of the insects emerging from a 1½- to 2½-year diapause the spring following the cone failure.

Defense in Lodgepole Pine

While most conifers of the boreal forests of North America are able to reduce the predation of their seeds by periodic regional cone failures interspersed with huge mast crops, lodgepole pine is a very informative exception to that pattern. Through the part of its range that extends from the eastern slope of the Cascade and Coastal Mountains in British Columbia through interior British Columbia, western Alberta and the Rocky Mountain states, lodgepole pine is adapted to reforesting areas after a forest fire. The cones are attached flatly against the tree branch by a thick tough stalk and will remain on the tree up to 20 or 30 years. They remain closed while on the tree by means of resin seals between the scales. When the trees are burned in a forest fire, the heat of the fire melts the resin seals and the cones slowly open. The fires often spread quickly through the forest, burning the needles and small twigs but leaving the trunk and most of the branches standing. The cones, which are still on the trees after the fire passes through, drop their seeds in the wind and they are distributed over the burned area where they can quickly germinate and start to reforest the area, often in thick, pure, even-aged stands of lodgepole pine.

Their adaptation to fire precludes lodgepole pines from making use of periodic cone failures to reduce the populations of their seed predators. If there are 20 to 30 years of cone and seed production still on the tree, it can not starve its predators by not producing one year. Because the seeds are available in a predictable position on the tree for so long, they have come under extreme selective pressure from squirrels which are the most powerful arboreal seed predators. The pine squirrels I watched would sample a few cones from a tree and if they could extract the seeds from the cones fast enough they would continue feeding from the tree until they had eaten all but a very few cones that escaped their notice. However, if the first cone or two provided seeds at a slower rate, the squirrel would leave the tree and sample another one. Elliott (1974) found that the hardness of the cone, the strength of the cone's attachment to the tree, and a low number of seeds per cone were the characteristics that inhibited squirrels from feeding on a tree. Each of these adaptive traits results in having the tree divert energy from seeds into woody protective tissue in cone scales. Where lodgepole pines have closed cones, only one

The remains of a squirrel's feast on lodgepole pine. The pile collected within a few days below a favored branch.

Photo: Sigurd Olsen

percent of the energy in a cone is expended on seeds.

However, along the Pacific Coast and in the Sierra Mountains where fire has been less of a historical factor, lodgepole pines shed their seeds the fall that they mature and the squirrels cannot subject them to such a severe feeding pressure to select for protective tissue in the cone. In this area, seeds comprise three percent of the energy in the cone, meaning that for the same amount of energy spent in reproduction, these trees produce three times as many seeds as the closed-cone race of lodgepole pine. Other conifers, which have periodic cone failures, have evolved cones with from 7 to 26 percent of their energy in seeds.

Timing Dispersal for Escape

There is a definite order in which squirrels attack the species among the group of conifers in the coastal forests of the Pacific Northwest which have cone failure and huge mast crops in phase with each other. Those with the biggest seeds and the most seeds per cone are chosen first. However, it is these preferred species that drop their seeds first.

All species of true firs *(Abies)* have relatively large seeds which are shed first, partly as a result of the cones' having deciduous scales. The seeds are not gathered by squirrels on the ground and they have thick seed coats in which there are twisting resin ducts which apparently inhibit mice from feeding on them. The resin is unusually sticky and coats the lips and nose of squirrels as they feed on *Abies* cones. It is likely that mice, which are more dependent than squirrels on sense of smell and touch, cannot afford to have their noses and whiskers fouled with resin. Abbott (1962) found that some captive *Peromyscus* would starve rather than eat *Abies* seeds.

Western hemlock seeds, at the other end of the size spectrum, occur relatively few to a cone and may remain in the cone six or seven months before they are shed in the spring. The seeds are among the last to be harvested by squirrels because of the small energy content of the cone and are available on the ground only a short time before they germinate, so that they are relatively safe from mice. Thus, the timing of seed dispersal among these species of conifers minimizes the exposure of each species to its most harmful predators.

Western redcedar is one exception to the correlation between small cone and seed size and late seed dispersal. It has the smallest seeds of the coastal conifers and yet sheds the seeds early in the fall. The reason for the exception seems to be that the seeds contain chemicals which inhibit feeding by mice and the seeds are safer on the ground than in the trees (Gashwiler, 1967).

Predators as Seed Dispersers

All the conifers described so far have both their seeds and pollen dispersed by the wind. However, most plants have one or both of these dispersal stages transported by animals and stand to lose the benefits of dispersal if they evolve patterns of regional reproductive failures. One of the most complex relationships to have evolved is one in which the dispersal agent is also one of the main seed predators. The interaction of oaks *(Quercus),* hickories *(Carya)* and walnuts *(Juglans)* with gray and fox squirrels in the deciduous, hardwood forests of eastern North America is one of the best examples of this relationship (although similar relationships are found between large-seeded pines and Clark's nutcrackers and piñon jays in montane forests, and between nut-producing trees and several species of large rodents in tropical forests). The animals in each case specialize in eating large seeds which are produced during one season of the year. In order to have the seeds during the rest of the year, they store them where other species of seed eaters are less likely to find them and yet can be retrieved by the animal that stored them.

Pine squirrels in the genus *Tamiasciurus* store cones in large caches in the center of their territories which they defend from all other individual pine squirrels. They can store food in a large concentration because there are no other species of animals in the area that can extract seeds from cones. However, gray and fox squirrels of the genus *Sciurus* would lose acorns that they piled in a central cache because they could not defend them from deer, raccoons, turkeys and perhaps some other large birds and mammals. Instead, these squirrels carry individual nuts away from the parent tree and bury them separately about one cm below the surface. By spreading the nuts out, the squirrels reduce

the chance that they will be used by large mammals that can only forage effectively on concentrations of nuts under the parent tree; and by burying them, they reduce the chance that acorns will be found by birds, which generally have a poor sense of smell. However, squirrels, and probably other mammals, can smell nuts even when they are buried.

Because the squirrels scatterhoard the nuts they store, they cannot see and defend the whole area where they bury nuts; consequently gray and fox squirrels have not evolved the territorial behavior which is used by pine squirrels to defend their concentrated caches.

Martin Stapanian studied the spacing that fox squirrels use in scatterhoarding black walnuts *(Juglans nigra)* in eastern Kansas. He thought that when an intruding squirrel found one nut that another squirrel had buried, it would search in the surrounding area, and if the nuts were buried too close together, it would find a second nut and continue to search all the harder. In order to find out what density of nuts would discourage the invader from forming a search image for buried nuts after it had chanced upon a first nut, Stapanian buried walnuts in grids of different density. He attached a piece of aluminum foil to each nut with tape so that he could check with a metal detector to see if the nuts have been removed without having to dig it up again each day. Walnuts spaced 8 and 16 feet apart in grids allowed squirrels to form search images and find most of the nuts in the grid after they discovered the first nut. However, nuts spaced 30 feet apart did not allow squirrels to form effective search images and most nuts went undiscovered.

Stapanian then watched squirrels scatterhoard nuts that he left in a pile in a cemetery and found that the five squirrels that visited the pile stored nuts in different locations around the pile and they averaged close to 30 feet between each buried nut and its nearest neighbor. The fact that the squirrels buried the nuts in different areas, even though they did not defend the areas, emphasizes the importance of maintaining wide spacing. If all five squirrels had each buried nuts at the optimum density, but in the same area, they would have created five times the optimum density and all lost their stored nuts to the intruders.

The maintenance of an optimum density means that as the supply of nuts increases, the

Squirrel with acorn of a white oak. In *A General History of Quadrupeds*. The figures engraved on wood by T. Bewick. 3rd ed. Newcastle Upon Tyne, 1792. Special Collections, Suzzallo Library.

distance the nuts are dispersed from the tree increases. However, the dispersal will do the tree no good if all the nuts are retrieved. The squirrels that bury the nuts must die, or forget where the nuts are buried, or bury more than they need if some of the seeds are going to germinate the following spring. John Fox has shown that many of the species of white oak (subgenus *Lepidobalanus)* acorns escape being eaten by germinating in the fall and forming a 4- or 5-inch root and a very small epicotyl, or stem bud, between the petioles of the cotyledons outside the nut. If a squirrel comes for the nut in the winter or spring, the petioles of the cotyledons break at a natural abscission layer leaving the seedling rooted in the ground. However, very little of the food value is left in the nut for the squirrel and John Fox (1974) found that many squirrels bite the growing tip of the acorn off before burying it so that it can not germinate. It turns out that most adult squirrels bite the tip and most juveniles do not so that successful acorns are those dispersed by juveniles.

The whole picture becomes more complicated and interesting by adding the fact that species of oaks, hickories and walnuts all have mast years, but not necessarily in phase and that squirrel populations vary considerably in size. If a good mast year follows a poor one, the squirrels that survive may all have large litters leading to a high percentage of juveniles and squirrels that could scatterhoard more food than they need.

Seeds in Edible Fruits

In addition to dispersal by wind and scatterhoarding seed predators, a third group of species have their seeds dispersed through the guts of vertebrates. The seeds are encased in a fleshy fruit rich in sugar or, in the case of some legumes, protein. The animals digest the fruit, but the seeds

usually pass through whole and land far from the parent tree. To prevent the seeds from being chewed and digested they are often encased in hard layers of material derived from the fruit or seed coats. The seeds may contain distasteful or poisonous materials which further inhibit heavy chewing. The edible part of the fruit is selected for being easy to digest and often acts as a laxative which further reduces the time the seeds are exposed to digestive enzymes of the gut. In general it is to the advantage of the plant to have the fruit nutritious for vertebrates but distasteful to insects and the seeds distasteful to all animals. These often conflicting selective pressures lead to a wide range of physical and chemical defenses (Janzen, 1971).

The variety of selective pressures influencing the evolution of seed predation, dispersal and germination lead to fascinating patterns of adaptations and numerous stories of complicated species interactions. Most of the stories are still waiting to be discovered.

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Unit Council Expands the Guide Program

A series of Guide Training Programs have been completed this spring, which has added a large number to the list of experienced guides trained and ready to lead tours — in the Arboretum, along the Native Trail or through the Japanese Garden.

The Native Guides' training consisted of: an orientation program by Elizabeth Moses; a talk on edible plants by Russ Mohney, Exploring Department Head for *Pacific Search* magazine; a program by Erna Gunther on plants used by the Indians; a tour of the Burke Museum; and a field trip to explore and study Foster's Island and the Waterfront Trail led by Della Patch.

The Japanese Garden guides saw a slide presentation and discussion of Japanese Gardens by Dorothy Lahr, Education Director of the Seattle Art Museum, and a slide program entitled "Hidden Language of Japanese Gardens" by Patricia Gutter, Assistant Professor of Landscape Architecture at the University of Washington. They met in the garden with Richard Yamasaki, who carried out much of the original rock work in the Japanese Garden, to discuss the history, design and plant materials used. With Mr. and Mrs. Kenneth Sorrells, they saw experienced guides in action and explored various ways of conducting tours for different age groups. Dee Woodley Johnson shared suggestions for tours for children.

The General Arboretum Guides had a series of seven on-site training sessions with Brian Mulligan. They studied the Arboretum in sections to become familiar with the plants. A list of plant material in each section, with interesting information about it, is being compiled to help in identifying the material by those visiting the Arboretum. Any one of these tours would make an interesting program for your unit.

RUTH MARY CLOSE

The Saga of Some Hybrid Seed:

Garrya fremontii × *G. elliptica*

*NAN BALLARD**

Two large, shiny-leaved garryas grow on the south side of the house where I enjoy the January display of six-inch greyish-white catkins of the male *Garrya elliptica.* Although its short, dull green catkins are much less spectacular in January, the female *G. fremontii* draws its share of attention in July when it drips with clusters of black fruit. The pair now block my view of the lower garden and must soon submit to drastic pruning. I admit, my interest in them may be less in their current ornamental value in their present unkempt state than in the intriguing story instigated by what Page used to call "hanky-panky on our front porch." Pat Ballard, former keeper of Funnybrook flora and fauna, wrote about them in "Some of Our Favorites" *(Arboretum Bulletin,* Summer, 1961, 24:2):

It was about ten years ago that Garrya Fremontii *first came our way and it was easy to see that several days had passed since the small, tired branchlet had left the parent plant. Being a devotee of the Else Frye school of propagating — "Take a cutting when you can get it" — we optimistically trimmed it, dipped it into rooting hormone and inserted it in a cutting mixture of 2 parts sand and 1 part peat moss. It survived our all-too-frequent inspections and grew in the protection of a cold frame until it was large enough to be planted out.*

Three plants of G. elliptica *were flourishing along the side of the house, in the hottest, driest situation that we could give them. So,* G. Fremontii *joined them, and when they were brushing the eaves and putting forth their first tassels, it had stretched to almost eighteen inches.*

During that villainous November of 1955, two of the tall Silk Tassel bushes went the way of most of our cherished garden plants. The one survivor sent out a few spindly shoots that were given all of the tender, loving care lavished upon any ailing member of our family. G. Fremontii *had lost only the tips of a few branches and behaved as if this had been just the stimulation for which it had been waiting. It is now a vigorous, five-foot mass of handsome, shiny green leaves and has bloomed heavily for several years, though its rather short, pistillate tassels have faded away without pollination.*

This year G. elliptica *once again reached the eaves of the south porch and produced two or three dripping tassels of gray-green flowers. That did the trick!* G. Fremontii *is drooping under the weight of its still-green fruits and we are impatiently counting the days until we can plant the seeds of what has to be a hybrid* Garrya. *While we wait we dream. Will it have the wonderful long tassels of* G. elliptica *with the varnished foliage and the greater hardiness of* G. Fremontii? *We can dream, can't we?*

PAT BALLARD

I have been unable to locate a specimen of this hybrid, planted anywhere on Funnybrook Farm's 20 some acres, but hope to remedy this omission in the near future.

Following Pat's article, *G. fremontii* apparently bore fruit copiously which was shared with the Arboretum for distribution in its inter-arboreta seed exchange from 1961 through 1964. Since 1966 there were, first, years when there was lots of seed to share; later, possibly after heavy December frosts, there were years when there was none. At some point, and I don't remember which year, I began to cut *G. elliptica* catkins of bloom heavy with pollen and balance them above the inconspicuous *G. fremontii* flowers with resulting return to the earlier heavy crops of fruit.

Some years ago, the late Lord Talbot de Malahide of Malahide Castle near Dublin, Ireland received seeds from our Arboretum and eventually planted a hedge of these hybrid plants in his castle gardens. In April, 1969 (p. 170), the *Journal of the Royal Horticultural Society* reported on the Ornamental Plant Competition held in London February 4-5 of that year:

Class 4 is for a vase of a shrub other than a Hamamelis, Rhododendron, or Camellia, and Lord Talbot de Malahide brought over for it an interesting and indeed attractive Garrya *which was a male seedling of a hybrid between* G. fremontii, *another Western American species, which is seldom, if ever, grown in this country* [*Britain*] *and has the reputation of being dull, and* G. elliptica. *This hybrid occured in a garden in Seattle, Oregon* [*sic*] *and it was from seed of this hybrid that Lord Talbot raised his plant. The foliage was much the same as that of* G. elliptica *but smaller. The* catkins *were also similar in length and form, but each bell of grey-green was circled with a band of red, giving the tassle a pleasant, light effect. It must be a matter of speculation from where the red band comes.*

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*The Editorial Board is grateful to Nan Ballard, its newest member, and to Brian Mulligan for having pulled together details surrounding the hybridization of two species of *Garrya* and the fortunate circumstances resulting from the distribution of that seed.

In the Proceedings of the Society for that year (p. 73) it was recorded that Lord Talbot's specimen had received an Award of Merit on that date.

In a subsequent issue of the same journal, April 1971 (p. 175), again reporting on a February show in London, is the brief statement: "Lord Talbot de Malahide's hybrid *Garrya* 'Pat Ballard' with grey and light orange tassles received the Award of Merit on Feburary 2. It should be as hardy as *G. elliptica* and with its lighter colouring be most acceptable." So far as can be determined, the specimen plant of *Garrya* 'Pat Ballard' was not then or later described for naming, nor is there any evidence that cuttings had been made of it before Lord Talbot's untimely death in the spring of 1973.

Since it is most unusual, even unheard of, for a particular plant to receive more than one Award of Merit or for a plant to be named without an official description, Brian Mulligan offered to write to the Royal Horticultural Society for clarification. We found the answering letter from E.M. Rix, Botanist, The Royal Horticultural Society's Garden, Wisley, Woking, Surrey, England sufficiently edifying to want to share it with you:

Dear Mr. Mulligan,

Your letter about Garrya *hybrid 'Pat Ballard' has been passed on to me. The plant was indeed recommended for an A.M. when exhibited on 4th February, 1969, but the award was withheld and should never have been published.*

I quote from the Minutes of Floral Committee 'B' of 15th April, 1969:

"The Secretary reported that the exhibit of Garrya (fremontii × elliptica) *which was recommended for an Award of Merit on 4th February, 1969, had included three slightly differing clones. After some discussion, the Committee decided that the award should only be given to the most outstanding clone, that the award should be withheld; and that Lord Talbot de Malahide, the exhibitor, should be asked to exhibit further material of a single clone next season."*

When Lord Talbot brought the plant a second time, in 1971, he made sure that the specimen was all of one clone, and duly received the A.M. As far as I can see from the file, no description of this was drawn up, and there is no specimen in our herbarium.

I knew Lord Talbot's garden at Malahide well, and I remember the Garrya *hybrid seedlings, which were grown as a hedge, male and female together. I wonder if the individual plant from which the vase exhibited in 1971 was taken was labelled, and so whether it is possible to obtain material from that clone. I will write to Mr. Brady and ask him to send a piece, as it should be flowering now, and if he does I will draw up a description for you. What characters are particularly important?*

Yours sincerely,
E.M. Rix

Mr. Mulligan had been in correspondence with Mr. Brady for some months when he received the letter from Mr. Rix. Also, nearly a year ago, I had written a friend in Dublin who had often visited the gardens at Malahide before Lord Talbot's death, but she found the castle gardens were closed because the estate was still in probate at that time.

Mr. Aidan Brady, Director of the National Botanic Gardens, Dublin, wrote to Mr. Mulligan:

Dear Brian, *July 14, 1977*

As requested in your recent correspondence we visited Malahide Castle Gardens early this month to locate the hedge of Garrya × *'Pat Ballard' planted by the late Lord Talbot.*

The planting you admired in 1970 is no doubt the one situated within the enclosed walled garden area. We found it to be in a reasonably thriving condition with individual plants in the hedgerow ranging from 17 feet in height to a low point of some 10 feet or so. At the moment it is draped with a prolific crop of fruit-bearing catkins from 4 to 5 inches long.

*A professional photographer attached to Dublin County Council (who recently acquired the Castle and Gardens) took some pictures of both hedge and catkins (close up) enclosed.***

There is some evidence of Winter tenderness but recovery would appear to be total, as Spring and Summer growth progresses. However, harsher Winters in the past may have taken their toll as at least 3 plants of the original hedgerow are no longer there, but of course the cause is not fully certain and there may well be other physical reasons to explain their absence.

Mr. Austin McCleary who was Head Gardener to Lord Talbot for many years is no longer associated with Malahide and it was not possible to get in touch with him for more authentic information.

An exhaustive search of Malahide Gardens failed to locate what you described as the 'original plant', and no one on our staff has knowledge of a Garrya under this cultivar name being offered in the trade.

Sorry about the colour photo's, but we could do some others later if you wish. We have a certain amount of difficulty because the estate was in limbo and it was impossible to gain access. I hope the foregoing is of some help.

Kindest regards,
Aidan Brady

It is heartwarming to find the lengths to which these individuals have gone to help us get the information we wanted. Another chapter of our story unfolds with Mr. Brady's next letter:

Dear Brian, *August 25, 1977*

Since my last letter and your reply we have succeeded in contacting Austin McCleary late of Malahide. He has identified the plant named "Pat Ballard" as

**The pictures to which Mr. Brady refers were not of sufficient clarity to show the specific characteristics of this hybrid.

the third plant in the line planted by Lord Talbot. Coincidentally this was the plant we selected as being the outstanding one to photograph. So the photographs you have are of the cultivar "Pat Ballard". We will take cuttings of this plant and try and build up a stock for distribution and next year we will examine the remaining lot to see if there is anything individualist enough to select, describe and name. It would indeed be appropriate to name after the late Lord Talbot.

Aidan Brady

We hope that through the efforts of Mr. Brady, Mr. Rix and Mr. Mulligan, it will be possible to get specimens of the original plant and the written description properly recorded to make *Garrya* 'Pat Ballard' A.M. officially acceptable. If there are further developments in our little hybrid garrya saga, we will give you a report later. ♠

Postscript

I hope I can find a spot at Funnybrook where I can plant a hedge similar to that at Malahide. It would be interesting, indeed, with its display of flowering catkins during January and February when our gardens are generally devoid of much outstanding bloom. If anyone else would like to try to grow some plants from future seeds of this cross, Funnybrook Farm would be happy to supply some.

N.B.

Garrya Hybrids at the Arboretum

Photo: UW Photography Lab

L. to R.: *Garrya elliptica* (male); *G. fremontii* × *G. elliptica* (379-61, male); *G. fremontii* × *G. elliptica* (42-62, female); *G. fremontii* (female).

Seeds of the hybrid *Garrya fremontii* × *G. elliptica* were received in August, 1961 from Mrs. Page Ballard of Issaquah, Washington. Only one plant appears to have been raised to planting size, and it was eventually set out on the bank on the west side of Arboretum Drive just north of the rock garden, near the south end of the Arboretum. This is believed to have been in November, 1964, but no record of the planting date is to be found on the pertinent file card.

The plant is now a handsome and vigorous male specimen 11 to 12 feet in height; it began to flower ten years ago and was in full bloom on January 18 of this year.

Six months after the Arboretum received Mrs. Ballard's seeds, in February, 1962, the late Carl S. English, Jr. gave us cuttings of two different *Garrya* hybrids which he had raised about 1956 or 1957. The first (Arboretum number 41-62) was from a cross between *G. elliptica* (seed parent) and *G. fremontii;* the second (42-62) had *G. fremontii* as the seed parent, *G. elliptica* the male parent.

Some of each of these were rooted and eventually planted out in several locations in the Arboretum, the first in April 1963 on the bank on the east side of Lake Washington Boulevard just north of the rock garden, later in 1964 and other years on the west side of Arboretum Drive and near the head of Rhododendron Glen.

There now remain five plants of number 41-62, which is a male plant; four are near the rock garden, one in Rhododendron Glen. They vary from 8 to 10 feet in height and were all in bud in mid-January, 1978. Its flowering time seems to be slightly later than that of other garryas in the Arboretum collections.

Number 42-62 proved to be a female plant, and of this clone three plants remain: two near the rock garden and one in Rhododendron Glen on a bank facing southwest. All were flowering at this date, as were the two parent species in various locations in the Arboretum and the fine male selection of *G. elliptica,* 'James Roof,' from California.

B.O.M.

The International Seed Exchange — or Fun and Games with *Index Seminum*

JOSEPH A. WITT

Perhaps one of the most fascinating aspects of Arboretum work revolves around the informal exchange of seeds among the world's botanic gardens and arboreta. Even though this exchange has no official recognition, it is an example of how cooperation among many small institutions in many countries can bridge barriers of language and politics. There is and was no "Iron Curtain" between western and eastern gardens and there are now gaps appearing in the "Bamboo Curtain" that hopefully predict a lowering of that particular barrier within a few years, at least as far as seeds are concerned.

The Arboretum has had an interest in seed exchanges from its very beginning, a fact well-documented in our acquisition books. These books are the records of all plants which are received by the Arboretum and date from 1936 to the present. In them each plant acquired is given a combination of numbers that remains with it throughout its life in the Arboretum. The first entry for 1936, 1-36, was seeds of *Aronia melanocarpa* from the Morris Arboretum, Philadelphia, followed by accessions of other lots of seed from older and more established gardens throughout the U.S. and abroad. Parenthetically it must be admitted that the black chokeberry plants derived from the seed of 1-36 died shortly after germination and are not part of the Arboretum's living collections.

The pattern of acquisition of seeds for Arboretum plantings established in 1936 continues in the same vein today, but with many more seed sources available. Major suppliers in the early years were primarily established American gardens such as the Arnold Arboretum in Boston, the Morris Arboretum, the New York Botanic Garden and the Brooklyn Botanic Garden. A few years later seeds came in from the two great Royal Botanic Gardens in the British Isles, Kew and Edinburgh, in such generous quantities that one is tempted to think the bulk of the Arboretum's more mature rhododendron collection was raised from seed received from those two institutions between 1938 and 1941. This poses a problem as I shall mention below.

During World War II there was naturally a period of quiescence in exchanging seeds, but in 1946 the entire procedure got into high gear again and began to expand. By 1953, when I first became active in the exchange, we were receiving (and sending) material to perhaps 100 other gardens. There are now 435 institutions on the exchange list with several new gardens added each year. The list is very cosmopolitan: we exchange seeds with 9 places in Africa, 32 in Asia, 13 in Australia/New Zealand, 95 in North America, 7 in South America, and the bulk of 297 in Europe including the U.S.S.R. It is this latter country with which we have the largest number of overseas contacts, 54. Next most numerous is the United Kingdom with 34 and then Germany, East and West, with 27. Not surprisingly the greatest number of exchanges is with gardens in the United States, 82.

Perhaps a word of explanation on how the exchange works would be in order. Each garden that wishes to engage in this project collects seeds during the summer and fall and then prints a list of the species available, the *Index Seminum.* These lists are mailed to all cooperating gardens, usually with a numbered form, the *Desiderata;* the recipient may then mark the seeds requested and return the list to the sender. After this exchange, the packets of seeds desired are mailed to the requesting institution.

Specifically speaking, the Arboretum sends out *Index Seminum* with from 200 to around 400 kinds of seeds offered. The number depends on the industry of the seed collectors, the season (that is, if the weather has been good for seed set), and whether seeds from wild stands have been collected. This latter often depends on the type of vacation the staff takes and where they go. As a personal note, I feel guilty if I do not take my vacation in the fall or if I don't go to

some location where I can collect seeds of wild plants

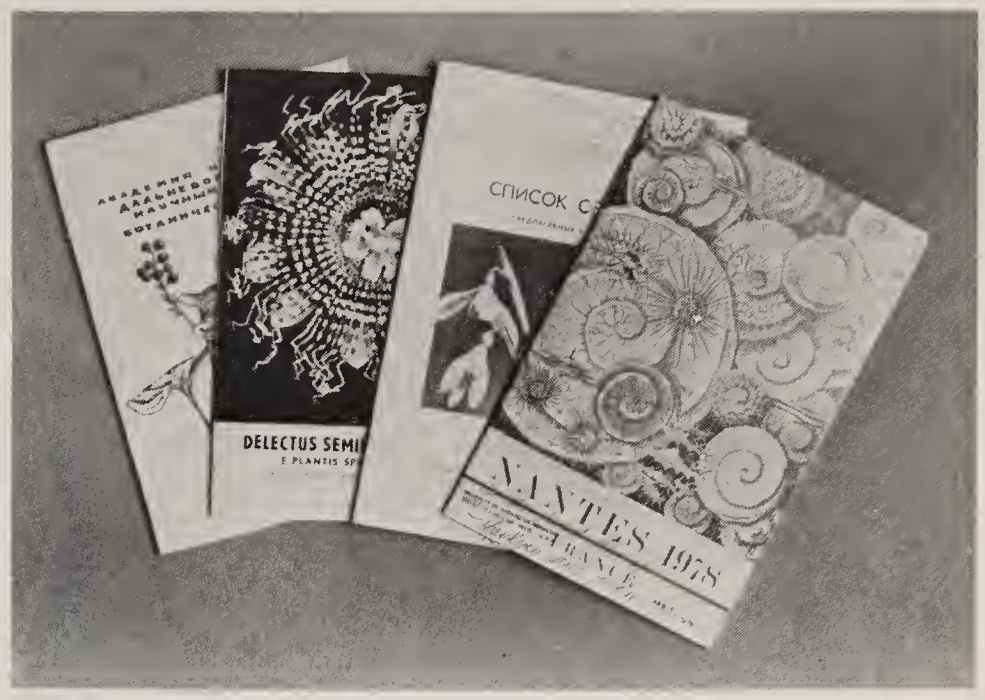
Our *Index Seminum* is quite modest when compared to many European gardens. It is not unusual to find as many as three- to four thousand kinds of seeds offered. Many have elaborate illustrated covers and are obviously expensive publications. Ours is a simple sheet of folded paper.

Filling the returned requests has been handled in this Arboretum by volunteers for nearly 20 years. The Vivian Mead Unit 66 is now doing yeoman duty as seed-packeters and envelope-stuffers.

How important is this exchange and why do we expend the time and funds necessary to keep the exchange active? The answer might well come from an examination of the source for plants now growing in the Arboretum. A rough estimate shows that about 55 percent of the total number of species on the Arboretum grounds were raised from seeds, obviously a very sizeable part of the collections. Even more important, seeds are a relatively simple way of introducing certain rare or hard-to-find species that might not otherwise be available.

As useful and vital as the seed exchange is to our plant introduction program, it has certain pitfalls that may trap the unwary. Bitter experience has shown that many seeds received from distant gardens have long since lost their viability. Well over half the seed sown in our greenhouse never germinate and we no longer bother to order seeds of certain genera such as *Quercus, Nothofagus, Salix* or *Populus* unless we are certain they were freshly collected and shipped airmail. Regretfully we have learned that one may not always be certain the name attached to the seeds will be correct, and that certain gardens have a reputation for sending out mislabeled material. It is an aggravating experience to raise and cherish some supposedly rare species only to discover you have been nourishing a viper in your bosom...when the plant flowers and an exact determination is made, the treasured plant turns out to be a nasty weed.

Even more common, and the major reason why some very fine gardens no longer offer seeds on a regular basis, is the chance that the seeds will produce hybrids. This is true of certain genera and especially true of seeds coming from gardens where many species of the same genera are



Examples of some of the seed lists received annually by the Arboretum. Photo: Nancy Walz

growing together. Rhododendrons are an excellent example of this tendency as are *Sorbus, Cotoneaster, Pyracantha, Cistus, Philadelphus* and many others. Unfortunately we realize that many of the fine old rhododendrons raised from Kew and Edinburgh seed in the 1940's are very apt to be hybrids, and that we have compounded the error by distributing seeds from these plants under the species name which came with the original seed.

Our policy now is to try to avoid seeds which we suspect may be of uncertain ancestry and wherever possible order those which were collected from native stands. Admittedly this eliminates the opportunity to add some material we may have need for, especially those species from western China now established in European gardens. However, it seems wise to avoid adding more possible hybrids to the collections and to wait until either the People's Republic of China relaxes its restrictions on foreign contacts, or to bring in scions or plants from those species in Europe known to have been raised from authentic collected material.

More and more seed lists now are emphasizing wild collected seeds, so I foresee a time in the not-too-distant future when this problem of seed hybridity will be of little consequence.

In summary, the international exchange of seeds has proven to be of the greatest benefit in developing the Arboretum's plant collections and even though there have been problems with wrong names and hybrid seeds, the bottom line has been the introduction of many fine rare and beautiful plants to the Arboretum and the Pacific Northwest. ♠

As You Sow . . . The A.R.S. Seed Exchange

*ESTHER BERRY**

Growing rhododendrons from seed is at once so easy and so very satisfying that addiction is almost inevitable. This being true, the Seed Exchange of the American Rhododendron Society was certain to succeed from the outset.

One could say that the Seed Exchange had its beginning at the Arboretum, for nearly half of the seed sent out that first year came from there. Now the seed program is indebted to the Arboretum for yet more assistance: members of the Arboretum Foundation Unit Council's study group, under the direction of Kay Ogle, have assumed the task of managing the seed program.

Since the first tentative beginning in 1963, our seed list has grown in quality, variety and volume. We now list around 700 items each year, and we have become the primary seed resource for rhododendrons throughout the world. The seed program is a major incentive to membership in the Society. This is especially evident in our constantly increasing foreign membership.

Possibly the most important factor in establishing the real value of the seed program was the number of generous contributions of hand-pollinated seed which came to us from the outstanding collections of some of the finest gardens in this country and abroad. This enabled us to offer seed from the choicest collected forms of the species, many of them are quite rare. Before that time, seed of this quality was almost non-existent.

Surprisingly, one of our greatest disappointments has been the consistently short supply of hand-pollinated seed from selected forms of our own native species. Perhaps our eyes are focused upon the rare exotics of other lands, and we do not see the opportunities close at hand.

No doubt, our greatest accomplishment has been the introduction of seed collected in the wild. Through the years, treasures from all over the world have poured into our coffers. They have come in bewildering variety from Japan, Taiwan, Korea, Sikkim, Bhutan, Nepal, India, Thailand, Switzerland, Austria, France, Borneo, New Guinea and even a few from Russia.

China, that mecca of all who worship the genus *Rhododendron,* has remained beyond our reach — until now. This year, for the first time, we have a small trickle of seed — unidentified, collected in the wild by forestry students — but still, a beginning. We *have* made contact.

Also of importance has been the hand-pollinated hybrid crosses. This portion of our list has become more sophisticated each year, and it has created a great amount of excitement, particularly the crosses with *R. yakusimanum.* For hybridizers, it has provided a ready-made system for growing on large populations of the crosses they have made. For the amateur who may not be able to make his own crosses, it is an opportunity to participate actively in this fascinating work. Further, it makes an exchange between hybridizers that can extend the scope of their endeavors.

In recent years there has been a burgeoning interest in the Malesian rhododendrons. We have had the great good fortune to be able to supply wild collected seed of several species, some not known to be in cultivation. We are still in the process of learning which of these species can be brought into cultivation; some are rather difficult, but their hybrids are less so. Considerable work is being done in hybridizing within this group and some spectacular hybrids have resulted. Again, we are fortunate in having knowledgeable members with the necessary resources to make such hybrids for us.

When one considers the cumulative effect of the tremendous number of seedlings that are being grown, one must conclude that we will eventually explore the full potential of the genus. Through selection, we will extend the range, improve the color and adapt the stature of these plants to suit our needs. Surely, we are engaged

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*Mrs. Robert Berry of Aberdeen, Washington, was the director of the American Rhododendron Society's Seed Exchange Program from its inception in 1963 until last autumn when she resigned from that position to continue her work as Executive Secretary of the Society. As she has said, she is a confirmed "rhodoholic."

For many years, Mrs. Berry was a valued member of the *Bulletin's* Editorial Board. We welcome this contribution, for we have missed her participation.

in an undertaking that will change the face of the earth.

The income from the seed program has provided an additional bonus for the Society. It has funded an extensive research program dealing with the problems related to the culture of rhododendrons. This in turn has resulted in the establishment of a research foundation.

The horticultural benefits of the seed program are easy to enumerate. Less obvious, but possibly more important, is the bringing together of our membership in a sharing of knowledge, resources and experience. This is a magic that can move mountains. ♠

Seed Sources Available to the Eager Propagator

The following list has been compiled by Linda Sheehan of the Arboretum Staff. It is hoped that it will be of some assistance to those readers who would like to grow unusual plants from seed.

GARDEN SOCIETIES (seed exchange among members only)

Alpine Garden Society of Great Britain
American Begonia Society
American Fern Society
American Gesneriad Society
American Gourd Society
American Hibiscus Society
American Horticultural Society
American Iris Society (species only)
American Magnolia Society
American Penstemon Society
American Rhododendron Society
American Rock Garden Society
Aril Society International
Palm Society
Scottish Rock Garden Society

COMMERCIAL NURSERIES

Miscellaneous Special Seeds

John Brudy's Rare Plant House, Box 84, Cocoa Beach, FL 32931 (rare and exotic vegetable and flower seeds)
Chesco, Box 10362, Santa Ana, CA 94025 (irradiated seeds for experimental purposes)
DeeDee's, Box 416, Menlo Park, CA 94025 (tropical seeds)
J.A. Demonchaux, 827 N. Kansas, Topeka, KS 86608 (special French vegetables)
De Sylva Seeds, 29114 Tanager St., Colton, CA 92324 (imported tropical)
Dow Seeds Hawaii Ltd., Dept. An, P.O. Box 30144, Honolulu, HI 96820 (trees, shrubs and foliage plants)
Peter B. Dow & Co. Ltd., P.O. Box 696, Gisborne, New Zealand (seeds of New Zealand and Australia)
Glecklers Seedmen, Metamora, OH 43540 (uncommon vegetables, many imported)
Gossler Farms Nursery, 1200 Weaver Road, Springfield, OR 97477 (trees, special magnolias and companion plants)
Honingklip Nurseries (Regd.) W.J. and Mrs. E.R. Middleman and Son, 13 Lady Anne Ave., Newlands, Cape, So. Africa 7700 (shrub and tree seeds of So. Africa) WHOLESALE ONLY
J.L. Hudson Seedsman, Box 1058, Redwood, CA 94064
Hurov's, Box 10387, Honolulu, HI 96816 (rare ornamental conifers and tropical seeds)
Kitazawa Seed Co., 356 Taylor St., San Jose, CA 95110 (uncommon vegetable seeds, many oriental)
Le Jardin du Gourmet, Box 119, Ramsey, NJ 07446 (uncommon French seeds)
Mail Box Seeds, 2042 Encinal Ave., Alameda, CA 94501 (uncommon vegetable and flower seeds)
Mellingers, 2310 W. So. Range Rd., No. Lima, OH 44452 (tree and shrub seeds)
Nichol's Garden Nursery, 1190 No. Pacific Hwy., Albany, OR 97321 (uncommon vegetable and flower seeds)
Clyde Robin Seed Co. Inc., P.O. Box 2855, Castro Valley, CA 94546 (uncommon vegetable and flower seeds)
F.W. Schumacher Co. (Horticulturists), Sandwich, MA 02563 (uncommon seeds: trees, shrubs and fruit)
Summerleas Farm, Kingston, Tasmania, Australia 7105 (special Australian tree and shrub seeds)
Sutton Seeds, 161 New Bond St., London W1 England
Van's Pines Inc., Box 739 West Olive, MI 49460 (softwood nursery)
Winsel-Gibbs Nursery, 31479 Pacific Coast Hwy., Malibu, CA 90265 (*Strelitzia regina* seeds — Bird of Paradise)

Cacti and Succulents

Abbey Gardens, Box 167, Reseda, CA 91335
Beahm Gardens, 2686 Paloma St., Pasadena, CA 91107
New Mexico Cactus Research, Box 787, Belen, NM 87002 (seeds only)

Herbs

Blue Ridge Ginseng, R. #1, Box 425, McDonald TN 37353
Capriland's Herb Farm, Silver St., Coventry, CT 06238
Cedarbrook Herb Farm, R. #1, Box 1047, Sequim, WA 98382
Comstock Ferre & Co., Wethersfield, CT 06109
Dunkled Acres. R. #3, Jersey Shore, PA 17740
Greene Herb Gardens, Greene, RI 02827
Charles C. Hart Seed Co., Wethersfield, CT 06109
Hemlock Hill Herb Farm, Litchfield, CT 06759

American Wildflowers

Carroll Abbott's Green Horizons, 500 Thompson Dr., Kerrville, TX 78028
Applewood Seed Co., Parfet St., Lakewood, CO 80215
Midwest Wildflowers, Box 644, Rockton, IL 61072

Of additional interest: *The Seedlist Handbook,* 2nd edition, by Bernard Harkness, which lists genera and species from selected seed lists published since 1972. Available through Kashong Publications, P.O. Box 90, Bellona, NY 14415. Price: $5.00.

Announcements from the Unit Council

New officers nominated for the coming year are:

First Vice-Chairman — Membership — Doris Taggart

Third Vice-Chairman — Greenhouse — Barbara Kottsick

Assistant Greenhouse Chairman — Mary Lou Nickols

Finance Chairman — Carol Simons

Secretary — Pat Moncini

Assistant Secretary — Sharon Goedecke

The Education Committee will sponsor another series of cutting parties this summer for those who wish to learn plant propagation, and for experienced gardeners who want to expand their collections. They will be held on the following mornings:

June 15 — Mae Granston, Woodinville. Deciduous azaleas and other plant material. Limit 12.

August 8 — Mary Dunnell. Greenhouse and house plants. Limit 8.

August 15 — Shirley Keith, Bainbridge Island. Azaleas. Limit 10.

August 23 — Betty Gray, Mercer Island. Choice material. Limit 8.

August 28 — Helen Moodie. Unusual material; cutting party at the Unit Council Greenhouse, Arboretum. Limit 12.

Flats with cutting medium, labels, rooting hormone, etc. will be supplied. Please list first and second choices and include a check for $3.00 payable to the Arboretum Foundation and labelled "Cutting Class." You will be contacted about your choice as soon as possible. Mail to: Mary Sambrook, 6867 83rd Ave. S.E., Mercer Island, WA 98040.

See also "Unit Council Expands the Guide Program" on page 28. *RUTH MARY CLOSE*

Garden Vignettes

A favorite combination of plant material in my garden came about quite by accident. My *Punica granatum* (pomegranate), obtained as a cutting years ago from the Arboretum, was planted in a semi-shady part of my yard. After giving it several verbal threats about the space it was using for its lack of bloom, I moved it to the top of a rock wall near the beach in full sun.

From then on it has been an absolute delight all summer long. Beginning in June, it has a steady bloom of bright orange-red two-inch double blossoms, appearing here and there but never covering the shrub. Although it is a non-fruiting variety, it earns its space by continuing to flower until the end of September. The flowers emerge from attractive shiny round brilliant orange-red buds and drop off in three to four days.

Companion plants must be used with caution, but my *Punica granatum* shares a spot with a large piece of gray driftwood and a group of summer-blooming hardy perennials. The most striking addition to this group is a clump of deep maroon-colored daylilies called 'Summer Interlude,' but the rest are mostly the low-growing Shasta daisy 'Miss Muffet' and the 15-inch flower spikes of *Veronica* 'Icicle' with gray-green foliage — reliable types which will bloom all summer long. I have a few orange *Geum,* a dwarf single variety which adds a little color, but does not seed everywhere and become a pest. A lovely addition to this planting is the perennial *Chrysanthemum haradjanii* with silvery-gray aromatic foliage, that stays a decent eight to ten inches in height and loves to grow along the edge of the sunny rock wall.

In September, the Kaffir lily species, *Schizostylis coccinea,* blooms around the base of my hard-to-use pomegranate. This is a member of the iris family and has grass-like leaves about 10 inches high. Its bright orange-crimson flowers are a good match and they finish the summer in a blaze of glory. *LEE CLARKE, Units 39 & 79*

If your dampened memory recalls anything at all about the winter of '66, I'll wager it was wetness — *forty straight days* (and nights) of liquid from the sky! This Kansan, recently moved here from Hawaii, reserved judgment.

But in February a miracle occurred. Not only

URGENT!

The Arboretum Buildings are overcrowded and we are preparing for the new Visitors' Center...

Therefore...

All excess *issues of the* UW Arboretum Bulletin *from its beginning (Volume 1) through Volume 38 (1975) will be sold for twenty-five cents (25¢) per copy on or before September 30th, 1978. Other, less available issues will be $1.00 each.*

Issues may be ordered on a first-come-first-served basis by enclosing list, phone number and check made payable to the Arboretum Foundation, Book Committee, and mailed to Mrs. Harry B. Slater, Arboretum Foundation, c/o UW Arboretum, XD-10, University of Washington, Seattle, WA 98195. These orders may be picked up at the Arboretum Foundation Office by appointment.

Back issues not sold before September 30th will then be disposed of to make room for the Arboretum files, library and herbarium.

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did the clouds part but in the garden of a neighbor across the street, a chorus of gloriously bright faces smiled back at the first rays of sunshine — Pacific Northwest primroses, I was told. For me this was an instant infusion of joy and the onset of a love of gardening Northwest-style!

Once again, when we bought our home the miracle was repeated — double front doors opened to an atrium view of Jean Marie de Montague in full bloom beside trickling water graced by exquisite fuchsia trees displaying flowers of the same hue. Ten years later our five-foot espaliered fuchsia trees continue to give us joy yearly from March to Christmas and welcome those who enter our home.*

To grow fuchsias as trees, select a single strong stem for development. Don't pinch the main tip on this stem but do remove most lower side branches. Start training the main stem to the shape you desire when it is still young and pliable. Fuchsias can grow from gallon-can plants into five-foot specimens in two years.

The American Fuchsia Society rates these as the 10 best upright performers: 'Checkerboard,' 'Cardinal,' 'Display,' 'Voodoo,' 'Erecta Novelty,' 'Royal Velvet,' 'Swingtime,' 'Rubeo,' 'Chang' and 'Lord Byron.'

MARY ANN TROMBOLD, Unit 79

*Mrs. Trombold tells us that she grows her fuchsias all year round in the atrium, which is enclosed on four sides but open to the sky. They lose their leaves in winter, but recover rapidly in spring. Twice (in the cold winters of 1969 and 1972) they have frozen to the ground but have resprouted at the onset of warm weather.

Book review

NORTHWEST TREES, by Stephen F. Arno and Ramona P. Hammerly. 1977. The Mountaineers, Seattle. Illustrated in black and white. Deluxe edition $30.00, paperback $5.95.

The deluxe edition was presented to the Arboretum in January by the Brian O. Mulligan Unit 79.

Stephen Arno's background and education in forestry makes him well-qualified to write about trees of the northwest maritime forest zone — southern British Columbia, Washington, the northern half of Oregon, northern Idaho and northwestern Montana. A native of the Puget Sound area, he studied forestry in Washington schools and received a PhD from the University of Montana. He has worked as a ranger and naturalist in national parks and now is a forest ecologist for the United States Forest Service.

In a relaxed conversational style, he tells about more than 30 trees of this area, man's uses and misuses of them, where good stands may be seen, insect and disease problems, and a little about the birds and animals that may be observed.

Another northwest native and member of The Mountaineers, Ramona Hammerly has lovingly illustrated the pages with forest scenes and detailed drawings of leaves, flowers and fruits of the trees described in the text.

Common names are used in the key, chapter headings, index and illustrations. Botanical names are included in the chapter headings. *Northwest Trees,* as part of the equipment taken on a "walk in the woods," will give much information and pleasure.

RUTH VOROBIK

Preliminary Results from the Plant Sale

Once more the Arboretum Foundation Plant Sale exceeded expectations. Despite the usual showery weather, gardeners arrived in sufficient numbers to spend over $20,000 during the hours from 4 to 8 p.m. on May 3rd. By the end of the sale on May 4th, the total gross profit had reached $42,000. The next issue of the *Bulletin* will include a more accurate figure as well as the estimated net profit, a large portion of which is traditionally earmarked for donation to the Arboretum.

University of Washington Classes

Spectrum, the quarterly journal for Continuing Education, is sent free to those who have indicated interest in the University of Washington's night courses, adult education classes, concerts and other cultural activities. Those who wish to obtain early notice of such classes are urged to place their names on the mailing list by calling 543-2590.

MOUNTAIN FORESTS — A WEEKEND AT PACK FOREST. Examine the plants, trees and adaptations of mountain forest communities near Mount Rainier in this intensive weekend at Pack Forest, the UW College of Forest Resources field research center near Eatonville, 65 miles south of Seattle. Field trips to virgin forests will emphasize the identification of native trees and shrubs. You will explore adaptive mechanisms which enable different species to flourish in a variety of environments from the Pack Forest foothills to the treeline communities on Mt. Rainier at Paradise. Lectures, slide presentations and demonstrations will provide background in evolution and forest ecology. No botanical background required. Participants are responsible for their own transportation to Pack Forest. Limited to 30. Wear sturdy shoes and all-weather clothes. Instructors: Linda Brubaker, Assistant Professor, Forest Ecology; and Patricia Duxler Penfield, Forest Resources and Arboretum. Friday evening, 8 p.m. through Sunday lunch; July 14-16; Pack Demonstration Forest; $67 (includes Saturday breakfast, lunch, dinner; Sunday breakfast, lunch; dormitory lodging, linens provided; field trip transportation). No refunds after July 7.

PLANT PROPAGATION. This course will cover the care and treatment of seeds, seedlings and bulbs; various methods for propagation by cuttings, divisions, budding, layering, grafting and fern spore germination; types of rooting media, fertilizers and soil composition. Lectures will include care and handling of plants in the home, garden and greenhouse. One field trip is planned. Students may take their plants home. Materials fee included. Instructor: Diane Varney, B.A., Botany, graduate student and dedicated plant lover. Wednesdays, June 28-August 16; 7:30-9:30 p.m. 9 sessions, including one field trip, $35 (all materials provided), parking $2.80.

EXPLORING SEATTLE III. The third offering of lecture/bus tours in the highly popular *Exploring Seattle* series. It will consist of seven evening-long field trips by bus with lectures enroute. Topics range from archaeology to farm land preservation to our relationships with the ubiquitous water — all to discover how Seattle's natural and man-made environments interact. Bus transportation, included in the course fee, leaves from campus. Coordinator: Polly Dyer, Public Services Coordinator, UW Institute for Environmental Studies. Wednesdays, June 28-August 9; 7-9:45 p.m. 7 sessions, $40, parking $2.45.

To register, obtain your copy of *Spectrum* with full information and registration forms. Call 543-2590.

New Members of the Arboretum Foundation

We are pleased to welcome the following new members (January 1, 1978 through March 31, 1978):

Sustaining – Mr. and Mrs. J.T. Handy, Lake Washington Garden Club #4. *Annual* – Nellie Bolstad, Mrs. Patricia Breinig, Kenneth R. Brooks, Margo Coad, Lowell Corda, Mrs. Brenda Culbertson, Alice Cunningham, Mr. and Mrs. John A. Cyra, Mr. and Mrs. John Danielson, Kathy Dennis, Mrs. David Diefendorf, Mrs. B.D. Elliott, Mr. and Mrs. William D. Forrester, Susan S. Foulk, Garden Valley Nursery, Inc., Linda Goldsworthy, Beverly H. Hall, Charlene W. Harris, Mrs. T.H. Ingley, Robert E. Johnson, Mrs. Marilyn Laird, Vicki M. Luhrs, Donald W. MacLeod, Joan A. McClendon, Ginny McElwain, Regina A. Padgett, Jeanne C. Powell, Mrs. Linda Powell, Mrs. Rivka A. Pratt, Brian Quigley, Janice Rabkin, B.J. Rotzler, Stein Skattum, Kay Stevens, William and Ann Tobin, Henry Todd, Monica Von Sydow, Mrs. Barbara S. Welsch, Mrs. Barbara G. Whittemore.

We are also grateful to the following who have increased their dues to:

Sponsor – Mrs. Kerry Trimble. *Supporting* — Mrs. William Boeing, Jr.

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It is thanks to them that we have been able to expand to forty pages.

CALENDAR OF EVENTS

Arboretum Foundation Board of Directors	September 14
Unit Council Governing Board	September 7
Unit Council Meeting	September 21

Most study groups meet irregularly during summer. For regular times the reader is referred to previous issues of the *Bulletin.*

For summer Explorers' Walks see Back Cover.

SPECIAL EVENTS

FERN SALE: sponsored by the Northwest Ornamental Horticultural Society. June 22 & 23, from 10 to 6; June 24, from 10 to 1. Bellevue Square.

SUMMER CUTTING PARTIES: see Announcements from the Unit Council, p. 36, for gardens and dates.

ARBORETUM FOUNDATION BULB SALE: a pre-order list with full information will be mailed in July.

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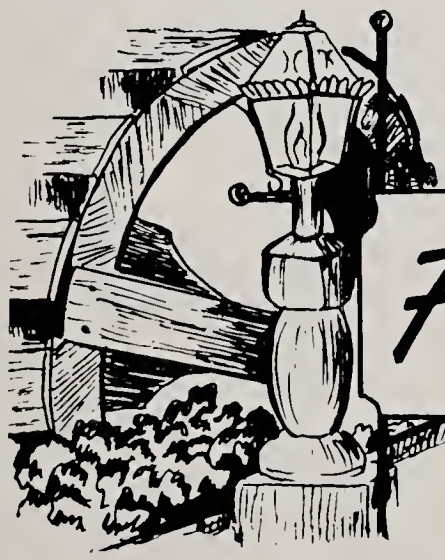

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Photo: Brian O. Mulligan

Magnolia sieboldii **blooming in early summer.**

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Enjoy the waterfowl in the Lagoon
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Walk on shady paths
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the *Cytisus battandieri* grow.

Join the Explorers' Walk, meeting every fourth Wednesday each month, in the parking lot of the administration buildings at 10 a.m. June 28, July 26, August 23 and September 27.